Computerized AHP Model for Solving BID/NO-BID Decision Problem

by

Abdalla A. Abdelrazig

A Thesis Presented to the

FACULTY OF THE COLLEGE OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
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This thesis is written by **Abdalla Abdelrahman Abdelrazig** under the direction of his Thesis Advisor and appoved by his Thesis Committee, has been presented to and accepted by the Dean of the College of Graduate Studies, in partial fulfillment of the requirements of the degree of **Master of Science in Construction Engineering & Management.**

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I dedicate this thesis to my late father, my mother and family.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

THESIS ABSTRACT

NAME OF STUDENT: ABDELRAZIG, ABDALLA ABDELRAHMAN

TITLE OF STUDY : Computerized AHP Model for Solving Bid/No-Bid Decision Problem.

MAJOR FIELD : Construction Engineering and Management

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This thesis presents a structured methodology to help contractors working in the Kingdom of Saudi Arabia to make their bid/no-bid decision on a rational basis. Literature was reviewed and thirty seven factors that affect the contractors bid/no-bid decision were found.

The Analytic Hierarchy Process (AHP) was used as a decision support model. Computer software named Expert Choice, based on the AHP and the bid/no-bid decision factors, was used to develop and solve the bid/no-bid decision model. A real-life example was used to demonstrate the application of the model and to help one of the major contractors in the eastern province to ensure the rationality of his decision to bid for a project in the Riyadh area.

MASTER OF SCIENCE DEGREE

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خــلاصـة الرســـالة

اسم الطالب : عبد الله عبد الرحمن عبد الرازق

عنـوان الرسـالة : نمـوذج باسـتخدام منهـج التحليل الهرمـي والحاسـب الآلـي لمسـاعدة المقاولين علي اتخاذ قرار الدخول في مناقصة.

التخصص : هندســة و إدارة التشييد.

تاريخ الشهادة : أكتوبر ١٩٩٥

تناقش هذه الرسالة نموذج باستخدام منهج التحليل الهرمي والحاسب الآلي لمساعدة المقاولين في المملكة العربية السعودية علي اتخاذ قرار الدخول في أي مناقصة أو الامتناع عنه علي أساس عقلاني. ولقد تم تحديد العوامل التي تؤثر في قرار المقاول وعددها سبع وثلاثون عاملا من المراجع.

تم استخدام أسلوب التحليل الهرمـي كمنهـج مساعد فـي اتخـاذ القرار. كما استخدم الحاسب الآلي والعوامل المؤثرة في قرار المقـاول فـي تطوير ومـن ثـم حل النموذج لاختصار الوقت اللازم لحل النموذج واتخاذ القرار. كما تم تطبيـق النمـوذج علي الطبيعة لعرض كيفية استخدامه ولمساعدة أحد كبار مقـاولي المنطقـة الشـرقية علي التأكد من عقلانية قرار الدخول في مناقصة لأحد المشاريع بمنطقة الرياض.

درجـــة الماجستير في الـــعلوم

جامعة الملك فهد للبترول و المعادن

الظهران ، المملكة العربية السعودية

CHAPTER 1

INTRODUCTION

With each bidding opportunity, the contractor should decide on a rational basis whether he should join the bidding or not. To make such a decision the contractor should evaluate all factors that will affect his bidding decision such as; project and company characteristics, project documents, the bidding situation and the economic situation(Abdul-hadi 1990, Ahmad 1990& Clough 1986). Entering and winning a bid of a certain project without considering the importance of the bid/no-bid decision making process, may lead to quality problems and huge losses to the contractor.

Although the determination of the factors that affect bidding is very important, but the contractor should be careful in selecting the decision support model that he is going to use to analyze those factors, insuring a rational basis for his bid decision.

The bid/no-bid decision is very important as it has profound effects on day- to- day operations and the long term performance of the construction firm (Ahmad 1990).

1.1 Problem Statement

It was evident from the findings of a questionnaire survey conducted among the top 400 contractors of the U.S.A. in 1986, that the bid/no-bid decision was made without any reasonable basis (Ahmad 1988). The basis upon which bid decisions should be made is usually not clear to bidders. The usual practice is to make bid decisions on the basis of intuition derived from a mixture of gut feelings, experience, and guesses (Ahmad 1990). Joining and winning a bid without weighting the bidding decision on a rational basis may generate a sequence of difficulties, which may prevent the contractor from fulfilling his contractual obligations. There are significant costs involved in developing and presenting a bid offer, and unsuccessful bid offers represent a substantial loss of investment.

The complexity of the bid/no-bid decision problem is so overwhelming that even experienced contractors feel that the industry should have a better technique for arriving at bid decisions (Ahmad 1990).

Previous efforts were made to list the factors affecting contractor's decisions on whether to bid or not (Abdul-hadi 1990, Ahmad 1990 & Clough 1986).

A structured methodology is still needed to allow contractors to use these factors to make bid/no-bid decisions. This will insure a more rational basis for bid decisions and also reflect a particular contractor's preference structure.

1.2 Research Objective, Scope & Limitations

The objective of this research is to develop a structured methodology supported with a computerized decision support model to help contractors to make their decision to bid or not to bid.

The methodology will use the list of factors reported in the literature, and will be flexible enough to allow the addition of other factors as necessary to fit a particular contractor's situation.

The study will be limited to contractors working in the construction industry in Saudi Arabia.

1.3 Research Methodology

Presents all the steps that will be performed to achieve the objective of this thesis. The procedures include all the data that is needed and where and how this data was secured, in addition to what decision support model will be used to solve the bid/no-bid decision problem.

1.3.1 Required Data

A through review of the literature was conducted for the purpose of assessing the factors that will affect the contractor's bid/no-bid decision in Saudi Arabia.These include both the contractor's internal as well as external factors. Through literature review, thirty seven potential influence factors were found that can affect the contractor's bid/no-bid decision in Saudi Arabia (Table 2).

1.3.2 Decision Support Model

The Analytical Hierarchy Process (AHP) will be used to develop and solve the bid/no-bid decision problem. AHP basic principles will be presented as well as the application steps required to come to a decision in complex problems. Specifically, the discussion will cover how AHP helps in establishing priorities in decision problems. Computer software based on AHP will be used to implement the methodology, in order to avoid excessive computations and simplify the decision making process. A real -life example will be used to demonstrate the application of the computerized decision support model.

CHAPTER 2

PREVIOUS STUDIES

This chapter covers the literature related to the bid/no-bid decision problem and the Analytic Hierarchy Process (AHP) applications in construction.

2.1 Bid/No-Bid Decision Problem

Researchers have been concerned with the problem of bidding strategy since the mid-1950s, when Friedman (1956) proposed a competitive- bidding strategy model with the objective of maximizing the total expected profit. The difficulty in determining the expected profit lies in determining the probability of winning as a function of the bid amount. The probability of winning can be determined when there is enough previous data to establish a bidding distribution curve of potential competitors. The probability of being lower than a certain competitor by bidding X is the area to the right of the ratio X/C on that competitor bidding distribution curve, where C represent the estimated cost of fulfilling the contract. The probability of beating a known number of competitors is the product of probabilities of beating those competitors separately. In the case of unknown competitors, Friedman suggested the use of the average bidders bidding distribution curve. He Also demonstrated how his method can be applied when bidding on a single contract or on several contracts simultaneously.

Gates (1967) treated seven different competitive bidding situations. Some of the strategies are for use by one contractor against competing contractors, and some can be used by contractors against the owner. The concurrent use of some of those strategies is also possible. For example, unbalanced bid strategy can be used with known bidders strategy. The most frequent situation is when the contractor bids against two or more competitors. Gates illustrated the use of each strategy by an example.

Benjamin (1979) reviewed the features of the Gates and Friedman models and traced the controversy between a number of writers who evaluated the correctness of these models in competitive bidding for construction contracts. He described a Monte Carlo simulation experiment performed at the University of Missouri-Columbia to compare results obtained by the application of the two models to an actual sequence of jobs. He concluded that Friedman's model always finds a smaller optimal markup to apply to the cost estimate than does Gates' model and the probability of winning at the optimal markup is less by Friedman than by Gates.

Based on the basic modeling approach of Friedman, Sugrue (1980) provides the practicing decision maker with an easily implemented method of approximating the bid which will maximize the expected value of the bid. Implementation of the model would require the compilation of past bidding data in order to compute estimates of the mean and standard deviation of the distribution of the lowest competitor bid to cost ratios.

Carr (1982) presented a general bidding model which is not limited to the assumptions on which Friedman and Gates models depend, and is applicable to any competition for which a contractor's cost distribution and opponents' bid distributions can be estimated. He claimed that his model fits the construction industry better than Friedman's model, because construction contractors' relative costs are random variables and represent the major variation among bids. Friedman's model is applicable to competitors whose relative costs are constant and whose bids vary only in their markups.

The problem situation is simplified in models presented above by assuming that profit is the only consequence and the index to be maximized is the expected value of profit.

Willenbrock (1973) provided guidelines which can be used to determine the utility functions of contractors involved in bidding situations. He presented a set of axioms that should be satisfied to guarantee utility function for the contractor's decision maker. He demonstrated graphically three basic shapes of utility function, that can represent a contractor preference in different economic conditions. He illustrated by an actual example, how the utility functions of a contractor can be obtained. The resulting utility functions of the contractor in the example, indicated that he tended to be risk averse when confronted with markup decisions on large size projects, and inclined to gamble when making decisions involving small or large markup on small size projects but risk averse in situations which represented a favorable markup level.

Moselhi (1993) developed a decision-support system that aids contractors in preparing competitive bids for building projects. The system used neutral networks for markup estimation that derive solutions for new bid situations based on analogy with past projects information. The system also provides the decision maker with some indications about the implications of the markup decision. These indications are win/loose possibility, estimated difference between the winner and second-lowest bidder, anticipated actual profitability, project potential for change orders and claims, and expected extension of duration.

From what was presented in the literature, it is found that the problem has always been treated as one of determining the probability of winning. Although determining the probability of winning is an important part of a bidding strategy, but it is not all. It should come as the second stage, since the contractor's first stage is to decide whether to bid or not to bid on a certain bidding opportunity. The bid /no-bid decision should reflect the contractor's preference. Very little, if any, attention has been given to the preference of the contractor.

Clough (1984) determined some of the factors that affect the bid/no-bid decision such as type of project,duraion,need for work and project cash flow.

Ahmad (1988) presented the findings of a questionnaire survey conducted among the top 400 contractors of the United States. The purpose of the survey was to identify the factors that affect bid decision.Forty eight factors were identified (Table 1).

Abdul-hadi (1990) investigated the factors affecting bid/no-bid and markup decisions, and studied their relative importance to contractors operating in Saudi Arabia. Thirty seven factors affecting the contractor's decision to bid or not to bid on a certain project were identified. These factors were classified into :- project characteristics, project documents, company characteristics, bidding situation, and the economic situation (Table 2).

TABLE 1 :Factors Affecting BID/NO-BID Decisions in U.S.A.(Ahmad 1990)

NO.	FACTOR	NO.	FACTOR
1	Type of job	25	Capital requirement
2	Need for work	26	Job start time
3	Owner	27	Labor requirements
4	Historic profit	28	General overhead
5	Degree of hazard	29	Equipment required
6	Location	30	Tax liability
7	Labor environment	31	Season
8	Strength of the firm	32	Contract Type & Term
9	Size of job	33	Type of bidding
10	Economic condition	34	Emerging market place
11	Competition	35	Job Schedule
12	Risk of investment	36	Future work
13	Current work load	37	Public exposure
14	Degree of difficulty	38	Logistics
15	Rate of return	39	Mediation clause
16	Confidence in workforce	40	Business plan
17	Uncertainty in estimate	41	Company growth poten.
18	Supervisory persons	42	Prevailing wage req.
19	Design quality	43	Time given to bid
20	Reliability of subcon.	44	Government req.
21	Project cash flow	45	Invitation or public
22	Contingency	46	Bonding Requirement
23	Duration	47	Change order poten.
24	Subcontracted amount	48	Project prestige

TABLE 2 : Factors Affecting Bid/no-Bid Decisions in Saudi Arabia (Abdul-hadi 1990)

A. PROJECT CHARACTERISTICS
Project cash flow
Size of contract in SR
Duration
Type of equipment required
Owner
Location of the project
Job start time
B. PROJECT DOCUMENTS
Owner special requirements
Type of contract
Design quality
Designer (A/E)
C. COMPANY CHARACTERISTICS
Availability of required cash
Uncertainty in cost estimate
Need for work
Experience in such projects
Confidence in work force
Strength in industry
Past profit in similar
General (office) overhead
Current work load
Availability of qualified staff
Establishing long relations with clients
Reliability of subcontractors
Portion subcontracted to others
Public exposure
D. BIDDING SITUATION
Required bond capacity
Competition
Time allowed for submitting bids
Bidding document price
Time for bidding (season)
Pre qualification requirements
E. ECONOMIC SITUATION
Availability of equipment
Overall economy (availability of work)
Risk involved in investment
Governmental division requirements
Quality of available labor
Availability of labor

Ahmad (1990) presented a structured methodology for modeling the bid/no-bid decision problem. The method was based on the technique of decision analysis. But this method, as other traditional decision analytic methods, has no formal way of dealing with inconsistencies (Harker, 1987). Rather these methods rely on the decision analyst's adhoc rules for the reconciliation of inconsistencies in judgements (Belton, 1986). In addition, the AHP contains an instrinsic measure of inconsistency for each matrix and for the whole hierarchy (Harker,1987).

2.2 The Analytic Hierarchy Process (AHP) applications in construction

The practical nature of the AHP for solving complicated problems has led to applications in highly diverse areas and has created a voluminous body of literature (Fatemeh, 1986). Some specific applications of AHP were listed by Fatemeh (1986) & Vargas (1990).

In the engineering field Hanratty (1992) illustrated the use of AHP for solving the problem of a chemical laboratory reactor selection. AHP was utilized to discriminate between many different reactor configurations.Mitta (1993) used AHP to rank a set of five computer interfaces designed for an automated part recognition system.The objective was to rank these interfaces on the basis of the user's perceptions regarding two interface characteristics : usability and learnability.

In the construction industry in specific, Reza (1988) proposed an integrated approach to project evaluation and selection. He overcame the drawbacks of goal programming by using AHP to set priorities and trade-offs among objectives. Mustafa(1991) overcame the limitations of the traditional approaches currently used by contractors to access project risks during the bidding stage, by using AHP. He applied it in the assessment of the riskiness of constructing Jamuna multipurpose bridge in Bangladesh.

Jeffery (1994) described a practical means for integrating technical, cost, and schedule risk components in a project management environment. The methodology depends on AHP as basis for eliciting utility functions representing the project manager's relative preference for technical, cost and schedule success.

John (1990) used AHP to view competitive bidding from a multiple criteria optimization perspective in which he considered capital exposure, work force continuity, risk reduction and profit as the decision maker's total utility.

CHAPTER 3

THE ANALYTIC HIERARCHY PROCESS

There are two fundamental approaches to solve problems: The deductive approach and the system approach. The deductive approach focuses on the parts whereas the system approach concentrates on the working of the whole (Saaty 1985). The analytic hierarchy process (AHP) is a decision aiding method developed by Saaty (1980). It combines these two approaches into one integrated logical framework. It aims at quantifying relative priorities for a given set of alternatives on a ratio scale, based on the decision maker's judgements through out the system. The AHP is a comprehensive framework which is designed to cope with the intuitive,the rational,and the irrational when making multiobjective, multicriterion and multiactor decisions with and without certainty for any number of alternatives. It is a method for deriving ratio scales used to integrate our procedure for representing the elements of any problem. It organizes the basic rationality by breaking down a problem into its smaller constituent parts and then calls only for simple pairwise comparison judgements to develop priorities in each hierarchy(Harkerk 1987). It a method we can use to integrate our perceptions and purposes into an overall synthesis.

3.1 AHP Features (Saaty 1985)

1- A practical way to understand complex problems by breaking them down into their constituent elements and measure the intangible qualities of those elements quantitatively to determine their priority impact.

2- A new way to integrate hard data with subjective judgements about intangible factors.

3- A technique complementing other ones (benefit /cost, priority, risk minimization) for selecting projects or activities.

4- It allows individuals or groups to shape ideas and define problems by breaking down their own assumptions and deriving the desired solution from them.

5- It provides a frame work for group participation in decision making.

6- It enables decision makers to perform a sensitivity analysis to the problem solution.

3.2 Structuring Hierarchies

Perhaps the most creative task in making a decision is to choose the factors that are important for the decision. Break down the complex problem into its constituent parts, and these in turn into their parts, and so on hierarchically. Through this process we can integrate large amounts of information into the structure of the problem and form a more complete picture of the whole system. At the top of the hierarchy lies the most general objective of the problem, such as the objective of making the best decision (or selecting the best alternative). The number of levels in the hierarchy depends on the complexity of the problem and on the degree of detail the decision maker requires to solve the problem. The lower levels of the hierarchy contain attributes (objectives) which contribute to the quality of the decision. Details of these attributes increase at the lower levels of the hierarchy. The last level of the hierarchy contains decision alternatives or decision choices. The decision model, hence, has a standard form as depicted in Figure 1 (Fatemeh 1986).

To a person unfamiliar with the subject there may be some concern about what to include and where to include it. When constructing hierarchies one must include enough relative detail to (Saaty 1990):-

1- Represent the problem as thoroughly as possible, but not so thoroughly as to loose sensitivity to change in the elements.

2- Consider the environment surrounding the problem.

3- Identify the issues or attributes that contribute to the solution.

4- Identify the participants associated with the problem.

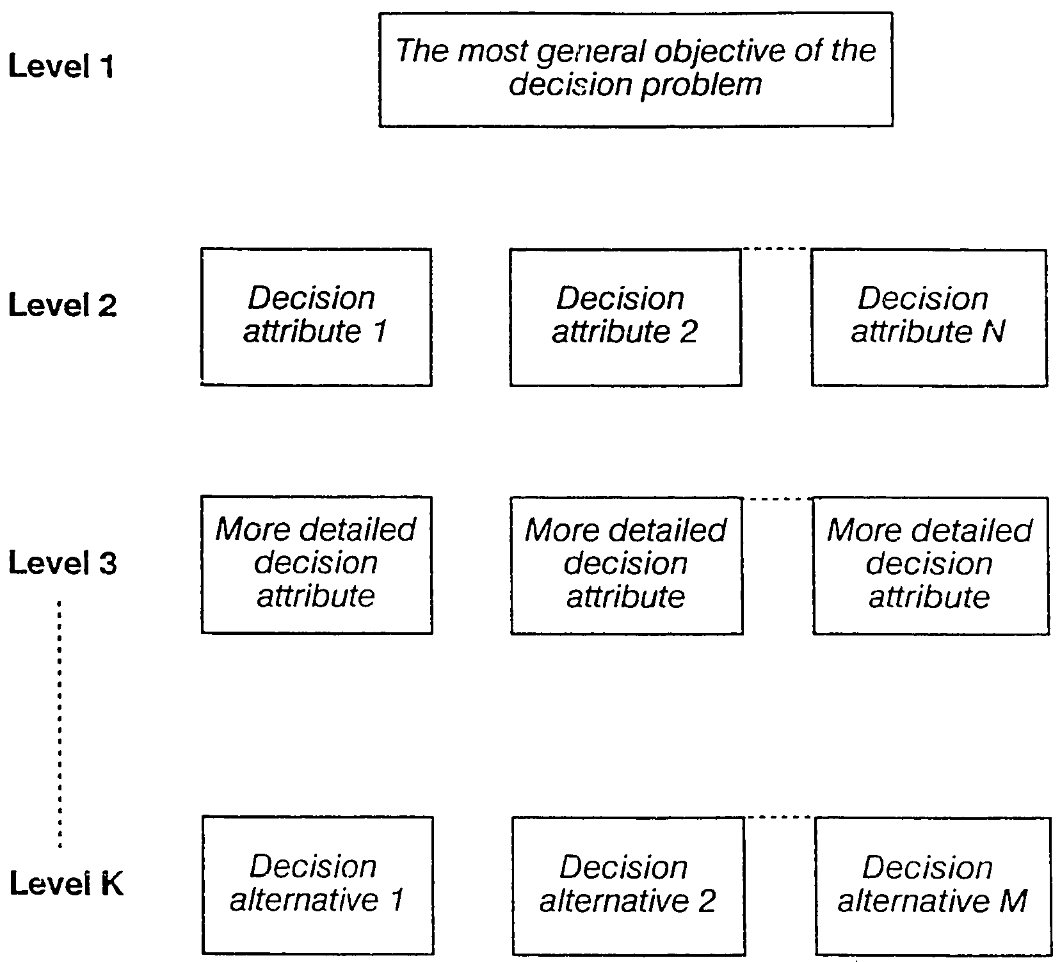


Figure 1 : The Standard Form of Decision Model In the Analytic Hierarchy Process (Fatemeh, 1986)

3.3 Measurement Scale

For a decision support theory to be trustworthy there must be uniqueness in the representation of judgements, the scale derived from these judgements, and the scales synthesized from these scales (Saaty 1990). In AHP there are two types of scale measurement to derive judgements and hence priorities which are:-

3.3.1 The Absolute Measurement

Absolute measurement needs standards to make it possible to judge whether the alternatives are acceptable or not. Absolute measurement is useful in students admission, faculty promotion, employee evaluation, and in situations where there is a considerable prior experience on which to base the scale (Saaty 1989), which then can be used to rate alternatives one at a time.

3.3.2 The Relative Measurement

It is a method of measurement that does not make use of standard scales. It is useful for properties for which there is no standard scale of measurement (love, political power, straightness). These are known as intangible properties. The number of such properties is extremely large. Relative measurement is essential to represent priority or importance if one is generating measurement by making direct observations and judgements about the property under study. A remarkable aspect of relative scales is that they can use information from standard scales when there is a particular need to do so (Saaty 1990).

3.4 Pairwise Comparisons

The most effective way to concentrate judgement is to take a pair of elements and compare them on a single property without concern for other properties or other elements. This is why paired comparisons in combination with the hierarchical structure are so useful in deriving measurement.

For pairwise comparisons, the matrix is a simple, well established tool that offers a framework for testing consistency, obtaining additional information through making all possible comparisons and analyzing the sensitivity of overall priorities to change in judgement (Saaty 1985).

In a complete system hierarchy, every element in the lower level affects every element in the upper level. But a hierarchy does not need to be complete, that is, an element in a given level does not have to function as an attribute (or criterion) for all the elements in the level below. An element in the higher level is said to be the parent element for these in the lower level since it contributes to, or affects it. The elements in the lower level are then compared to each other based on their effect on the governing element .

The scale to use in making judgements is given in Table 3. This scale has been validated for effectiveness, not only in many applications by a number of people, but also through theoretical comparisons with a large number of other scales (Saaty 1990).

When comparing alternatives the term preference is appropriate and the term importance is appropriate when comparing one criterion with another. Table 3 will be used to express these judgements as integers (Saaty 1985).

The element that appears in the left-hand column of the matrix is always compared with the element appearing in the top row, and the value is given to the element in the column as it is compared with the element in the row. If element A dominates element B, then the integer is entered in row B column A. Of course, if element B dominates element A then the reverse occurs. For n elements there are n(n - 1)/2 judgements required to develop the required matrix (Saaty 1985).

One may argue that it is possible to assign weights directly to elements of a level. The argument in AHP is that such direct assignment of weights is too abstract for the evaluator and results in inaccuracies (Fatemeh

Table 3: The Pairwise Comparison Scale (Saaty 1985)

Intensity of Importance	Definition	Explanation
1	Equal importance of both elements	Two elements contribute equally to the property
3	Weak importance of one element over another	Experience and judgement slightly favor one element over another
5	Essential or strong importance of one element over another	Experience and judgement slightly favor one element over another
7	Demonstrated importance of one element over another	An element is strongly favored and its dominance is demonstrated in practice
9	Absolute importance of one element over another	The evidence favoring one element over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between two adjacent judgements	Compromise is needed between two judgements
	If activity i has one of the preceding numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

1986). Pairewise comparisons, on the other hand, give the evaluator a basis on which to reveal his or her preference by comparing two elements. Since each level entails pairwise comparisons of its elements, Saaty (1980) suggests that the number of elements at each level be limited to a maximum of nine. This constraint, however, is not a necessary condition of the method and has not been adhered to in all applications (Fatemeh 1986).

The pairwise comparisons process should be performed for each level in the hierarchy with respect to the level just above. This process can proceed from the top and go downward (evaluating the importance of the criteria and then the preference for the alternatives) - or from the bottom upward (evaluating the preference of the alternatives with respect to each criterion before evaluating the importance of the criteria). Unless the decision maker is familiar with the alternatives and the tradeoffs that affect them, it is usually best to proceed from the bottom up. By doing this, he gain insights into the tradeoffs involved and will be in a better position to evaluate the relative importance of the criteria.

3.5 Clustering

Comparisons of elements in pairs requires that they be homogeneous or close with respect to the common attribute, otherwise significant errors may be introduced into the process of measurement. Clustering is the process of grouping elements with respect to the common attribute.

The question then is how to perform clustering of homogenous elements in an efficient way to facilitate paired comparisons when there is a large numbers of elements.There are three ways to perform clustering on large number of elements. Ordered from the least to the efficient way, they are (Saaty 1990):-

3.5.1 The Elementary Approach

Given n elements in a level of the hierarchy, first make a pass through them by comparing one element with another, dropping it and picking another if that one is perceived to be larger and continuing the comparison. The process is repeated for the remaining n-1 elements tc identify the second largest element and so on.

3.5.2 Trial and Error Clustering

Alternatives may be put into groups of large, medium and small. Then the elements in each group are put into several clusters of a few elements each, and a first pass at comparisons is used to identify misfits which are then taken out and put into the appropriate one of the other two categories.

3.5.3 Clustering by Absolute Measurement

Each alternative is evaluated by absolute measurement for an attribute in descending order on that attribute. For many problems, it is useful to carry out first absolute measurement to sort and cluster the elements, and then follow that with relative measurement for greater accuracy.

3.6 Synthesizing to Get Results

Synthesizing is the process of weighting and combining priorities through the hierarchy that leads to the overall result.For all matrices obtained in the pairwise comparisons step, synthesize to get an overall estimate of the relative weights of each matrix elements with respect to the parent element. To do this, first add the values in each column. Then divide each entry in each column by the total of that column to obtain the normalized matrix, which permits meaningful comparison among elements. Finally, average over the rows by adding the values in each row of the normalized matrix and dividing the rows by the number of entries in each. The result of this is a vector of priority of all matrix elements with respect to the parent element (Saaty 1985).

Aggregate the relative weights of various levels of the model in order to produce a vector of composite weights which serve as ratings of decision alternatives (or selection choices) in achieving the most general objective of the problem. The composite relative weight vector of elements at kith level with respect to that of the first level may be computed from (Fatemeh 1986):

$$C(I,K) = \prod_{i=2}^{k} Bi$$

where :-

C(I,K): is the vector of composite weights of elements at level kith with respect to the element on level 1.

Bi : is the n_{i-1} by n_i matrix with rows consisting of estimated eigenvectors.

ni : represents the number of elements at level i.

Repeating this simple aggregation yields relative weights of elements at the lowest level of the hierarchy (where choices are located) with respect to the most general objective of the decision at the first level.

3.7 Consistency

AHP makes a useful contribution to test out the degree of inconsistency, namely the Consistency Index (CI) (Saaty 1983). This measure is useful in identifying possible errors in expressing judgements as well as the actual inconsistencies in the judgements themselves. The consistency Index (CI) can be calculated for each matrix as follows :-

CI $= (\lambda - n)/(n-1)$

n : matrix size

λ : Eigenvalue

An approximation to the eigenvalue can be calculated by multiplying the total of each column in a judgement matrix by its corresponding vector of weights. The approximation is exact when the exact vector of priorities is used.

The consistency can be checked by taking the Consistency Ratio (CR) of CI with the appropriate one of the following set of numbers shown in Table 4(Saaty 1983). Consistency Ratio (CR) should be 10% or less.

The Consistency Index of the entire hierarchy is obtained by multiplying the Consistency Index of each matrix by the priority of the criterion used for the comparisons , and add all such quantities .

Size of Matrix	Random Consistency	Size of Matrix	Random Consistency
1	0	6	1.24
2	0	7	1.32
3	0.58	8	1.41
4	0.9	9	1.45
5	1.12	10	1.49

TABLE 4 : Random Consistency Set of Numbers (Saaty, 1985)

To check the consistency of the entire hierarchy, compare the Consistency Index of the hierarchy with its counterpart when the consistency indices of all matrices are replaced by average random judgement consistency indices for matrices of the same size (Table 4). The CR should not exceed 10%. If it is more the quality of the judgements should be improved, perhaps by revising the manner in which the questions are asked in making the pairwise comparisons. If this fails to improve consistency, then it is likely that the problem should be more accurately structured, that is, grouping similar elements under more meaningful criteria. A return to priority setting would be required, although only the problematic parts of the hierarchy may need revision (Saaty 1983).

3.8 Making Group Decisions (Saaty 1985)

The AHP can be used successfully with a group. In fact, brainstorming and sharing ideas and insights often leads to a more complete representation and understanding of the issues than would be possible for a single decision maker.

When the Analytic Hierarchy Process is used in a group session, the group members structure the problem, provide the judgements, debate the judgements, and make a case of their values until consensus or compromises reached. In an ideal situation the group is small and the participants well informed, highly motivated, and on agreement on the basic question being addressed. They are also willing to participate fully in a rigorous, structured process whose outcome will partly determine their future activities, no matter what differences of opinion still surround the result of the process. Again ideally, the group is patient enough to reconsider the subject so that, through iteration, the remaining differences of opinion are debated and an agreement is reached or at least the range of differences is narrowed.

But such a scenario is the exception. Often the participants are unequal in their expertise, influence, and perspective, and cooperation may take some coaxing by the leader. Patience on the part of the leader and the group is highly desirable, and unhurried structured group discussion can yield a more satisfactory outcome than one achieved quickly and with little debate.

3.8.1 Getting the Best Results

When applying the AHP in a group session, several factors may affect the quality of the results. Some have to do with the individuals involved, some with the process itself.

The number of people in the work group is significant. It is desirable to have many people participate in constructing the hierarchy. The more ideas offered,the richer the representation of relevant issues.

But analyzing the elements of the hierarchy can become unwieldy if too many people with diverse points of view are included. It is better to form smaller subgroups for priority setting.

The status and expertise of the group leader or a member can influence the outcome. Usually this is to the good, because experience and informed judgement contribute to a better understanding of complex situations. But everyone should be encouraged to participate, even if the range of judgements widens. As a group become more experienced in using the AHP, consistency should improve.

The stake of group members is another factor. Generally the AHP should be used for group interaction only when a majority have a genuine interest in the outcome of the process and are willing to be opened-minded about the possibilities.

In constructing the hierarchy, the number of levels in the design may affect the quality of the results. The levels should relate naturally to each other. If necessary, a level may be expanded into two or more levels or eliminated. The criteria employed in each level should be of the same order of magnitude and relate to at least two elements in the level immediately below. A study may be required to identify and characterize elements that are relevant to the issue in question.

Most of the problems in applying the AHP occur in the priority-setting stage. Particularly when the process is being used for the first time, the number of elements being compared and the order in which the comparisons are made should be carefully monitored. The more elements in a level, the greater the chance of inconsistency and the more taxing the comparisons process. On the other hand, a sufficient number of elements should be listed to represent the issue adequately. As a rule, it is best to compare the strongest and the weakest elements in a level first. The resultant value serves as a guidepost for the other comparisons.

Attributes perceived through the sense can be evaluated more precisely than those recalled from memory or abstract ideas. The meaning of the values in the pairwise comparison scale must be clearly understood. It is best to state the verbal judgement first (A is strongly or weakly more important than B) and then translate it into its numerical value. Allowing enough time for debating priorities is critical. The more carefully the judgements are made, the more valid the conclusions. Consensus is not essential at the lower levels of the hierarchy, but it is needed at the higher levels, where the priorities drive the rest of the hierarchy.

3.8.2 Preliminary Steps

First make sure that the participants are comfortable and well provided with writing materials, refreshments, adequate lighting, and so on. If the AHP is being used for the first time, explain how it works and illustrate it with simple applications. Large flip charts are convenient for this purpose . Allow for a question- and-answer period.

It may be helpful to have two discussion leaders with one or two assistants. A group session that lasts for two days, typical for planning, is quite taxing , and much of the pressure on either leader is reduced by having the other carry on when necessary. A computer terminal makes it possible to obtain answers immediately and to test the consequences of judgements with respect to sensitivity and consistency.

A good way to begin the session is by brainstorming the overall focus of the problem or plan. Several suggestions may be made, from which one is selected as most representative of the current overall concern. The important thing is to define the objective of the discussion clearly at the very beginning.

3.8.3 Constructing the Hierarchy

With the focus determined, the group defines the issues to be examined and constructs the hierarchy as richly as possible to cover the issues. The discussion should be relaxed and unhurried. The leader reminds the group that the purpose of the meeting is to construct the hierarchy and, through discussion, debate, and the use of pragmatic imagination to make pairwise comparisons from which priorities are set for the elements at the lowest level of the hierarchy. Overhead transparencies may be used to record entries in the hierarchy and matrices. After the hierarchy is completed, it should be drawn, typed, and distributed to all the participants. Before proceeding to the judgements, revisions are made and the hierarchy is retyped and redistributed.

Breaking down a complex issue into different levels is particularly useful for a group with widely varying perspectives. Each member can present his or her own concerns and definitions, no matter what the level may be. Then the group is assisted in identifying the overall structure of the issue. In this way agreement can be reached on the higher-order and lower-order aspects of the issue through a clustering and ordering of all the concerns that members have expressed.The group then agrees on how it will proceed to make decisions. The whole group might start at the top level and then progress to the down ones. It may delegate to subgroups the responsibility of considering, subdividing further, or setting priorities on a particular level. Or it may choose a combination of these alternatives.

3.8.4 Setting Priorities and Synthesizing

Group priority setting is by nature interactive and noisy and involve bargaining and persuasion. This lively interaction need not be perfectly orchestrated - the participants may feel regimented and intimidated. Those who have no patience for the process should be allowed simply to observe or, if they wish, to leave the room and return when the process is completed. A leader should also be sensitive to the unspoken words of group members. Some need coaxing and encouragement to participate or to express their feelings. In a large group the process of setting priorities is easier to handle by dividing the members into smaller, specialized subgroups, each dealing with an issue of particular interest or one in which members have special expertise. When the subgroups rejoin for a final justification, the values in each matrix can be debated and revised if desired.

Taking the geometric mean of individual judgements is one way to resolve a lack of consensus on values after debate. Another method of resolving conflict is to vote on the proposed values. The final solution can also be obtained as a range of values that represents the range of judgements. if for some judgement the suggested judgements are far apart, it may be useful to try first one judgement, then another,to find which yields a higher consistency with the rest of judgements.

The AHP does not subvert or force human nature. There is no guarantee that all aspects of dissent can be harnessed, nor should they be. Dissent is a valuable basic process that should not be banned in group interaction. But dissent must eventually lead to some kind of cooperation if anything is to be accomplished.

3.8.5 Special Problems

The leader of a group session should be prepared to deal with the following problems:-

1- Unequal Power and Experience.

2- Variable Preferences.

3- Change in Preferences.

4- Unwillingness to Reveal Preferences.

3.9 Decision Support Software

``Expert Choice'' (version 8) is the name of the software. It is based on the Analytic Hierarchy Process (AHP). Expert choice assists a decision maker in solving complex problems involving many criteria and several courses of actions. It organizes the various factors of a problem into an upside-down tree hierarchy.

The tree branches downward from the goal. Intermediate levels represents the factors, objective, or the criteria, of the problem. At the bottom of the tree are the leaves which represents the alternatives of choice.

The decision makers judgments form the basis of the Expert Choice Process. Expert Choice does not make a choice in some mysterious way, or assume that the answer is hidden in the elegance of the underlying mathematics, but helps the decision maker to make an informed choice based on his knowledge, experience and preferences.

The Expert choice Software package consists of an introduction manual, a getting started booklet and disks. For the software installation, cababilities, and instruction commands refer to the software manual (Saaty 1986).

CHAPTER 4

SOLVING BID NO/BID DECISION PROBLEM

In this chapter, the computerized decision support software (Expert choice - version 8) was used to structure the Bid/No-Bid decision model, and a real-life bidding opportunity was used to solve the bidding decision problem to come to a rational decision.

4.1 Structuring Bid/No-Bid Decision Model

The computer software and the factors affecting the Bid/No-Bid decision making in Saudi Arabia (Abdul-hadi 1990) were used to develop the Bid/No-Bid decision model. Expert Choice user manual instructions were followed to edit the bid/no-bid decision model as an upside-down tree hierarchy. The model name is Bidding Decision. Bid or Do not Bid on a certain bidding opportunity was the goal of the decision maker was located at level 0 of the model and served as the goal node. Factors affecting contractor's decision to bid, which had been classified into 5 categories (Abdul-hadi 1990), were inserted in level 1 of the model to serve as main criteria. Each category factors were inserted in level 2 of the model to serve as sub-criteria nodes, except the company`s characteristics category.

In the company's characteristics category there were 14 factors, and that exceeds the limit of 7 nodes, which is the maximum allowed by the software to be compared together to get a satisfactory result under a single parent node. To go beyond the limit of 7 nodes, Expert Choice instructions in such case were followed. Three dummy nodes, named Set A, B, and C were inserted below the company`s characteristics node. Then, the 14 factors were inserted as follows: 5 factors below Set A, 5 factors below Set B, and 4 factors below set C.

Finally Bid and No/Bid decisions were inserted below the hierarchy leaves to serve as the choice alternatives for the contractor's decision maker.

Model node names and their definitions were shown in table 5. Main nodes of the hierarchy were highlighted and copied to show the model tree (Figures 2 to 10). Sideways view command was used to display all the levels of the model at once (Fig. 11).

4.2 Solving Bid/No-Bid Decision Problem

The Bid/No-Bid decision model was solved to help M/s M.S.Al-Suwaidi for Contracting Establishment (MSAS), Ras -Tanura,KSA, to insure the rationality of their bidding decision on the New Pharmaceutical Formulation Plant, 2nd Industrial State, Riyadh.

TABLE 5: Model's Node Names & Definitions

NODE NAMES	NODE DEFINITION
PRO.CHA.	Project Characteristics
P.CA.FL.	Project cash flow
CON.SIZE	Size of contract in SR
PRO.DUR.	Duration
RQ.EQ.T.	Type of equipment required
OWNER	Owner
PR.LOC.	Location of Project
JO.ST.T.	Job start time
PRO.DOC.	Project Documents
OW.S.RQ.	Owner special requirements
CON.TYPE	Type of contract
DES.QUL.	Design quality
A/E	Designer (A/E)
COM.CHA.	Comapny Characteristics
AV.CASH	Availability of required cash
COST EST	Uncertainty in cost estimate
WORK ND	Need for work
EXPER.	Experience in such projects
WORK FCE	Confidence in work force
INDUSTRY	Strength in industry
PROFIT	Past profit in similar
OVERHEAD	General (office) overhead
LOAD	Current work load
STAFF	Availability of qualified staff
CLIENTS	Establishing long relation with clients
SUBCONT.	Reliability of subcontractors
OTHERS	Portion subcontracted to others
EXPOSURE	Public exposure
BID.SIT.	Bidding situation
REQ.B.C.	Required bond capacity
COMPET.	Competition
T.A.S.B.	Time allowed for submitting bids
PRICE	Bidding document price
TIM.BID.	Time of bidding (season)
PRE.REQ.	Prequalification requirements
ECO.SIT.	Economic Situation
AVA.EQU.	Availability of equipment
OVER.ECO.	Overall economy (availability of work)
RI.I.IV.	Risk involved in investment
GOV.D.R.	Governmental division requirements
QL.AV.L.	Quality of available labor
LAB.AVA.	Availability of labor
BID	Bid for this project
NO/BID	Do not bid for this project
SET A	Company Characteristics Set A
SET B	Company Characteristics Set B
SET C	Company Characteristics Set C

Bid or Do not Bid for This project

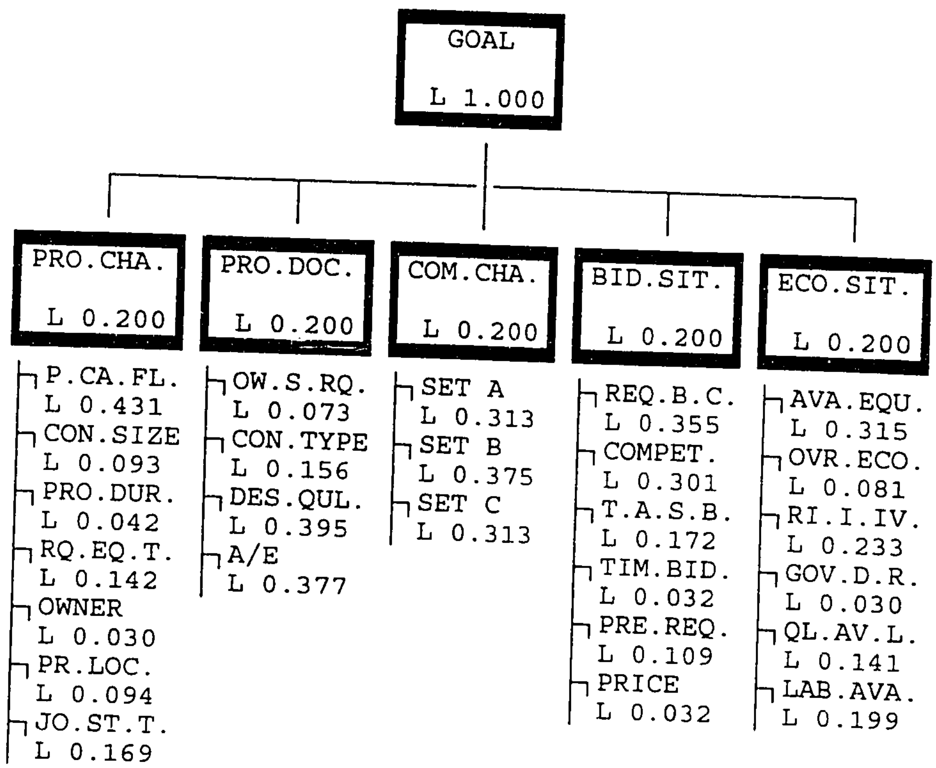


Fig. 2: Bidding Decision Model Displayed From the Goal Node .

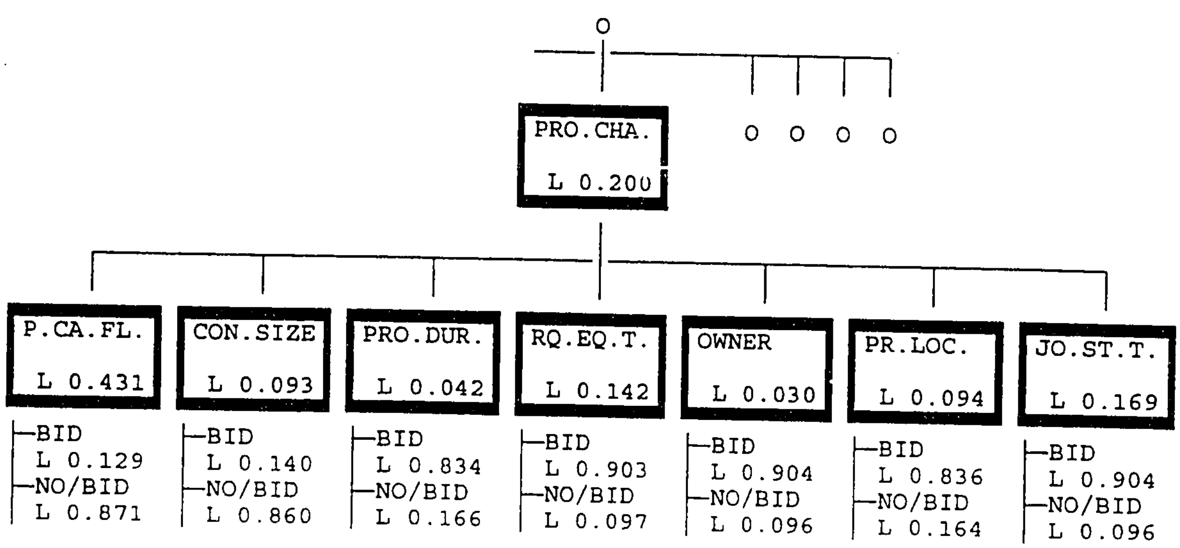


Fig. 3: Bidding Decision Model Displayed From the Project Characteristics Node .

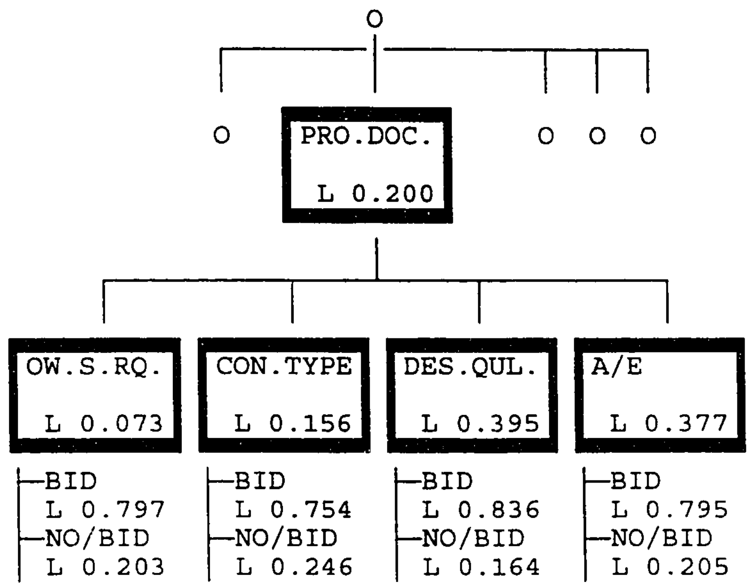


Fig. 4: Bidding Decision Model Displayed From the Project Documents Node .

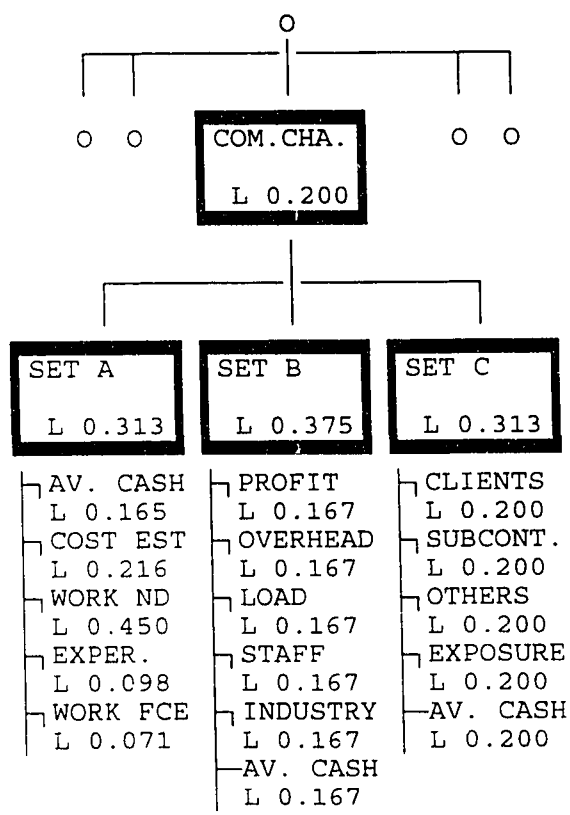


Fig. 5: Bidding Decision Model Displayed From Company's Characteristics Node .

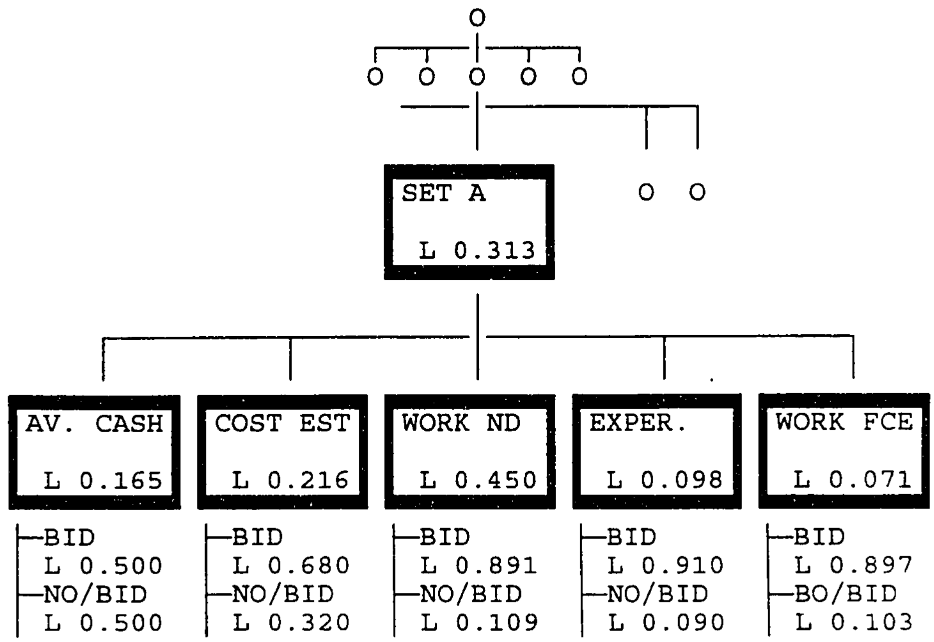


Fig. 6: Bidding Decision Model Displayed From Set A Node.

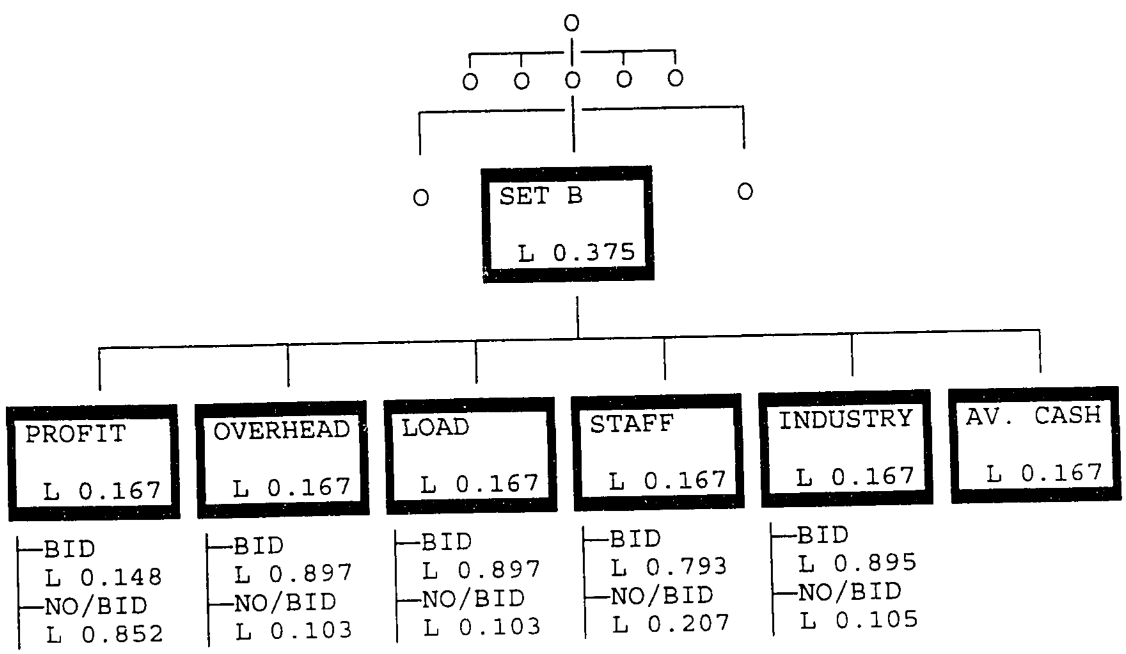


Fig. 7: Bidding Decision Model Displayed From Set B Node .

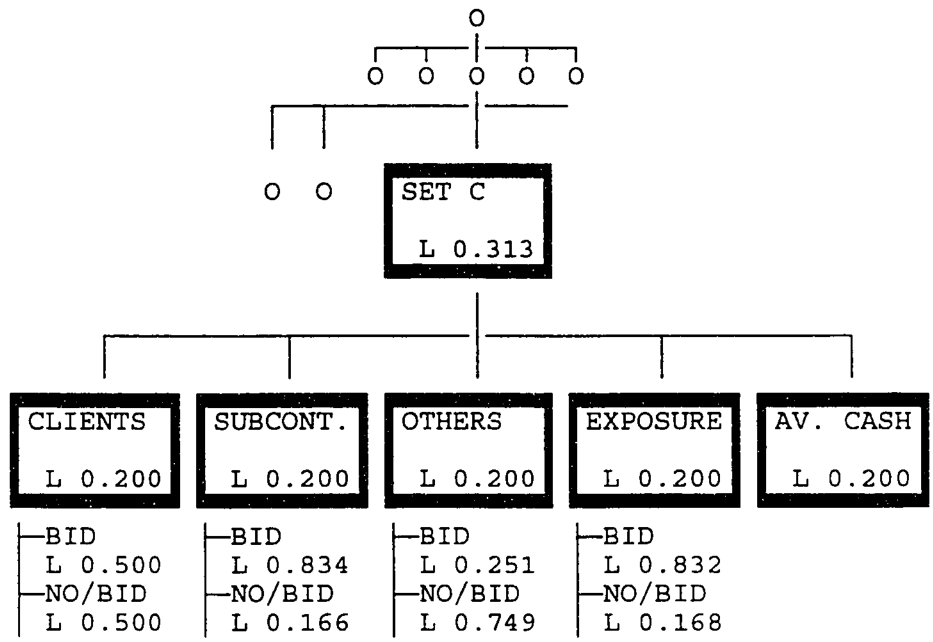


Fig. 8: Bidding Decision Model Displayed From Set C Node.

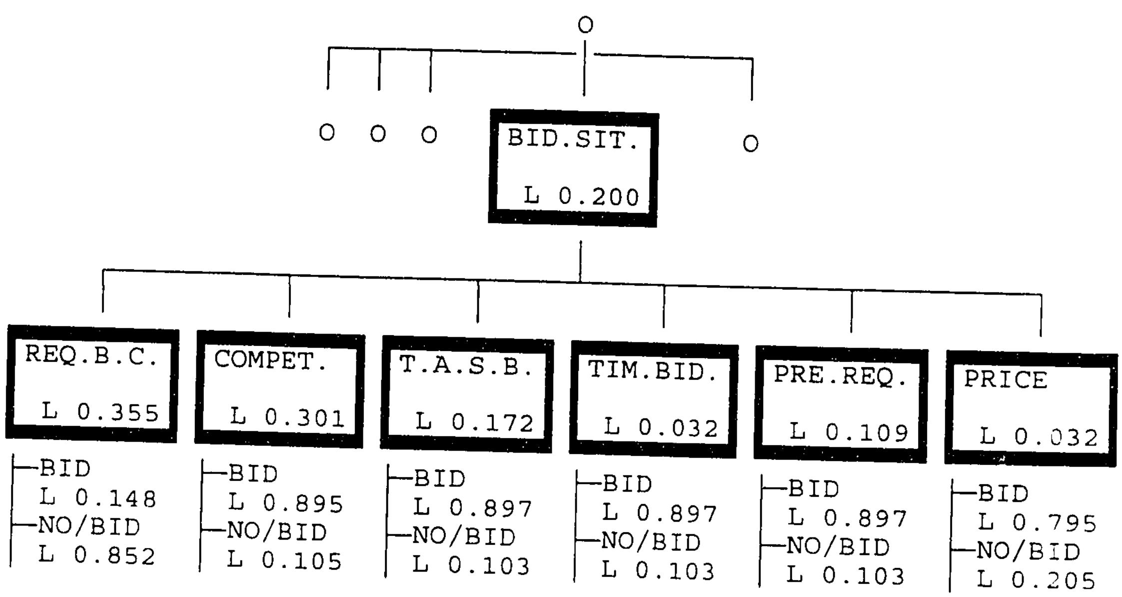


Fig. 9: Bidding Decision Model Displayed From Bidding Situation Node .

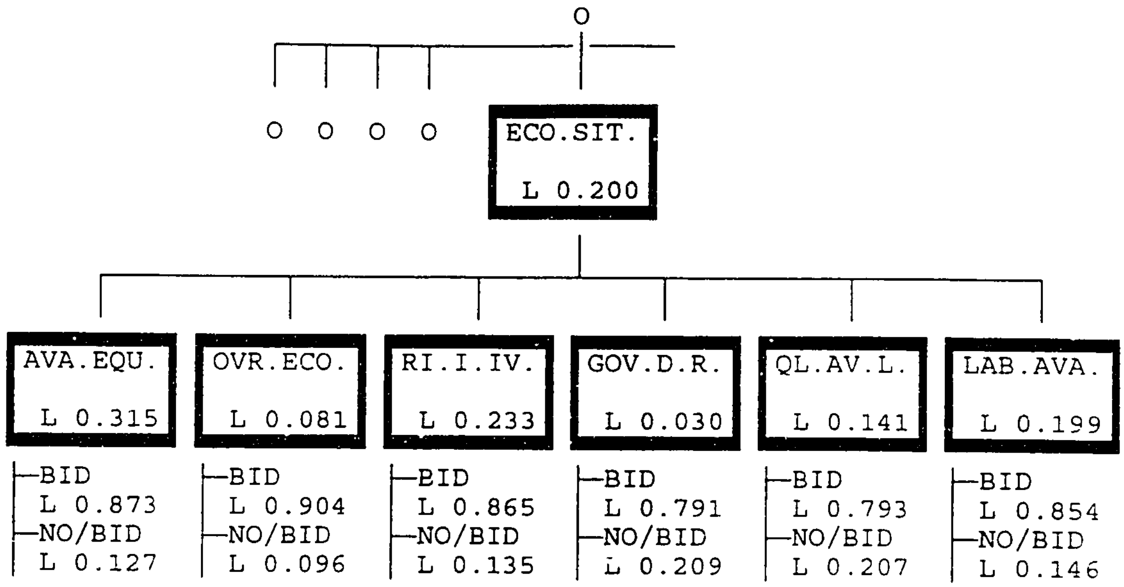


Fig. 10: Biding Decision Model Displayed From Economic Situation Node .

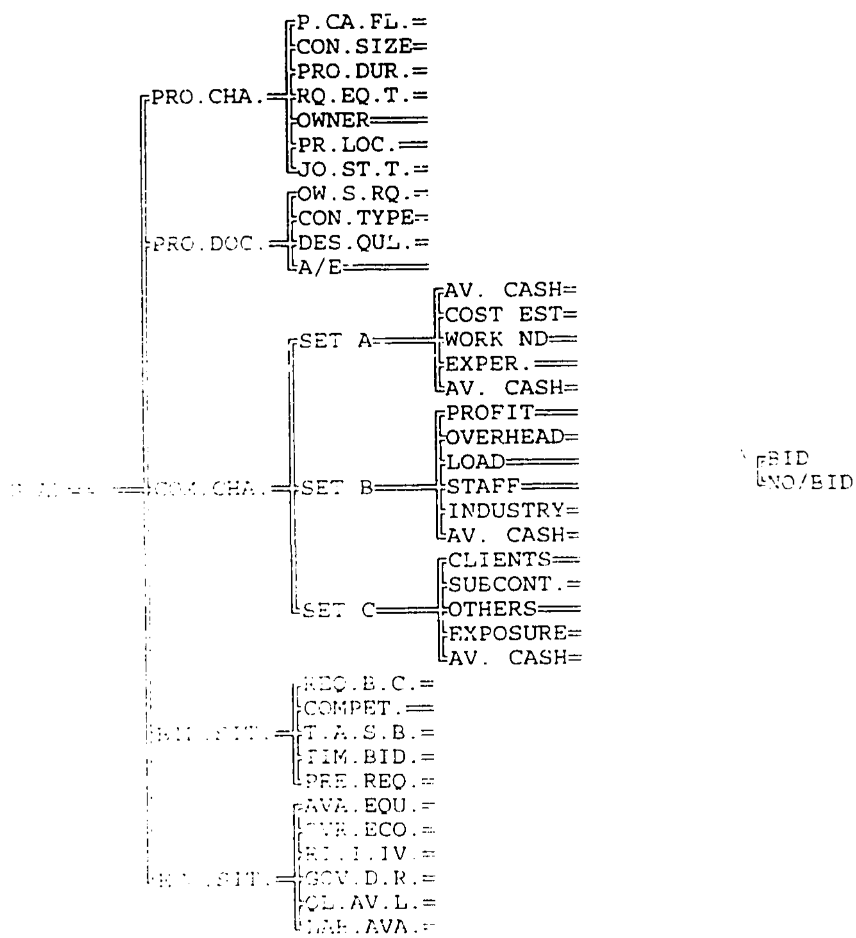


Fig. 11: Side Way View of the Bidding Model .

4.2.1 Goal Definition

The goal of the decision model was defined as to Bid or not to Bid on the New Pharmaceutical Formulation Plant (Fig. 12).

Bid or Do not Bid for the New Pharmaceutical Formulation Plant

- GOAL L 1.000
  - PRO.CHA. L 0.087
    - P.CA.FL. L 0.431
    - CON.SIZE L 0.093
    - PRO.DUR. L 0.042
    - RQ.EQ.T. L 0.142
    - OWNER L 0.030
    - PR.LOC. L 0.094
    - JO.ST.T. L 0.169
  - PRO.DOC. L 0.061
    - OW.S.RQ. L 0.073
    - CON.TYPE L 0.156
    - DES.QUL. L 0.395
    - A/E L 0.377
  - COM.CHA. L 0.336
    - SET A L 0.337
    - SET B L 0.448
    - SET C L 0.215
  - BID.SIT. L 0.157
    - REQ.B.C. L 0.355
    - COMPET. L 0.301
    - T.A.S.B. L 0.172
    - TIM.BID. L 0.032
    - PRE.REQ. L 0.109
    - PRICE L 0.032
  - ECO.SIT. L 0.359
    - AVA.EQU. L 0.315
    - OVR.ECO. L 0.081
    - RI.I.IV. L 0.233
    - GOV.D.R. L 0.030
    - QL.AV.L. L 0.141
    - LAB.AVA. L 0.199

Fig. 12: The NEW Pharmaceutical Plant Bidding Decision Model Displayed From the Goal Node .

4.2.2 Information Screens

To form a more complete picture of the problem, an information screen for each factor affecting bidding

decision was established (Appendix 1). This information was collected by the company decision maker from the various departments of the company,and it was used as a base for developing judgements throughout the model.

4.2.3 Entering Judgments

To familiarize the company decision maker with the alternatives and the tradeoff among them, the pair -wise comparison process was performed from the bottom of the model upward (Saaty 1986).

The preference of the company decision maker among alternatives with respect to each bidding factor was judged, and since there were only two nodes in the comparison set, the Graphical Comparison Mode was the default (Figures 13.1 to 13.37).

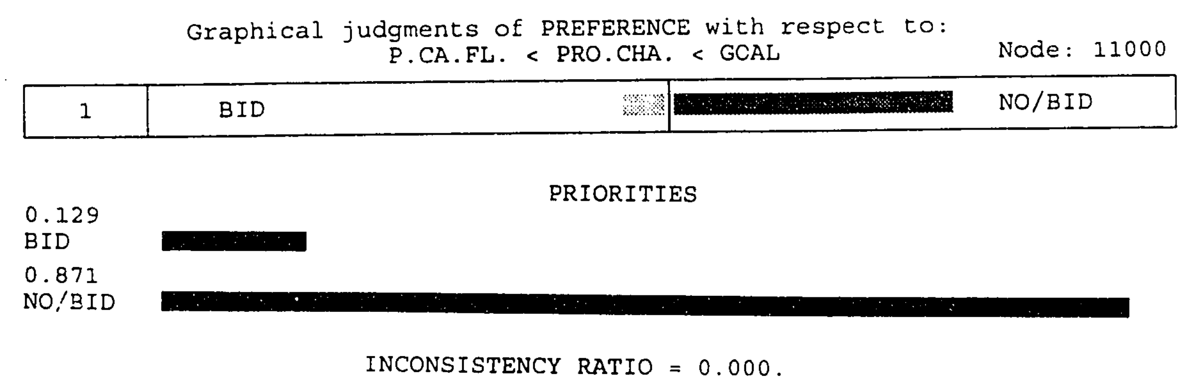


FIG. 13.1 Judgement & Priorities Of Alternatives with respect Project cash flow

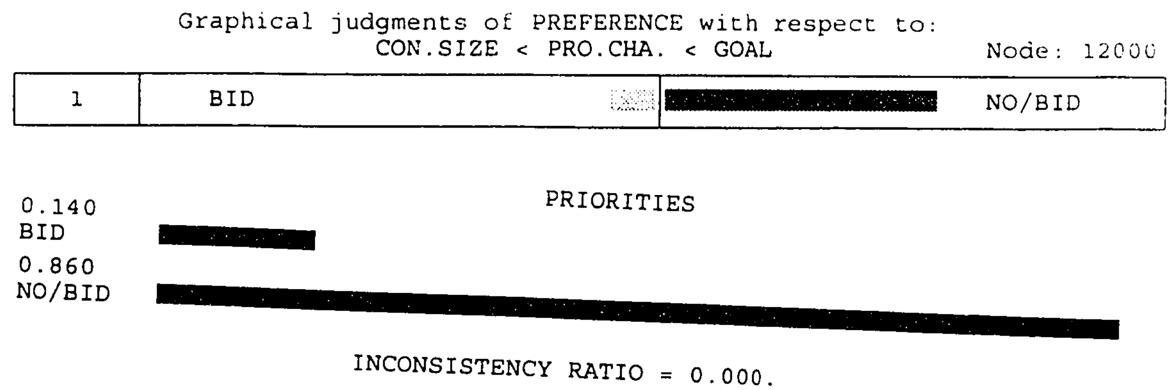


Fig. 13 .2 Judgement & Priorities Of Alternatives with respect

Size of contract in SR

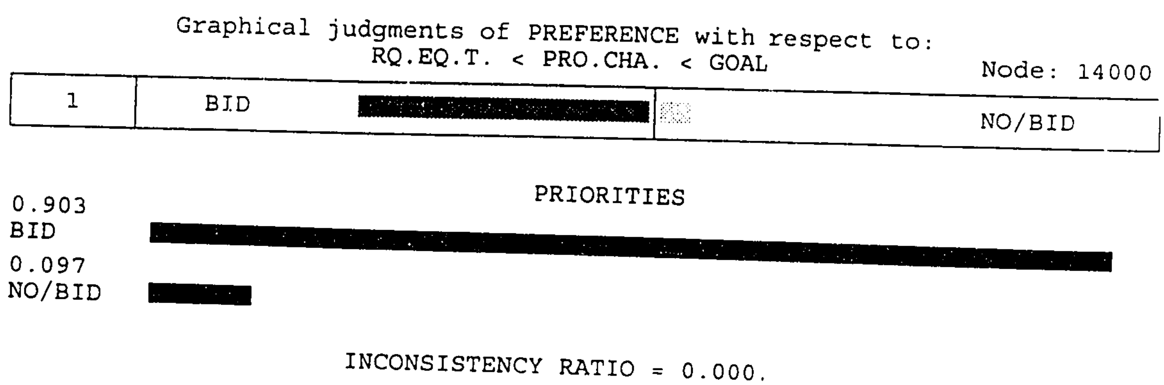


Fig. 13 .3 Judgement & Priorities Of Alternatives with respect

Type of equipment required

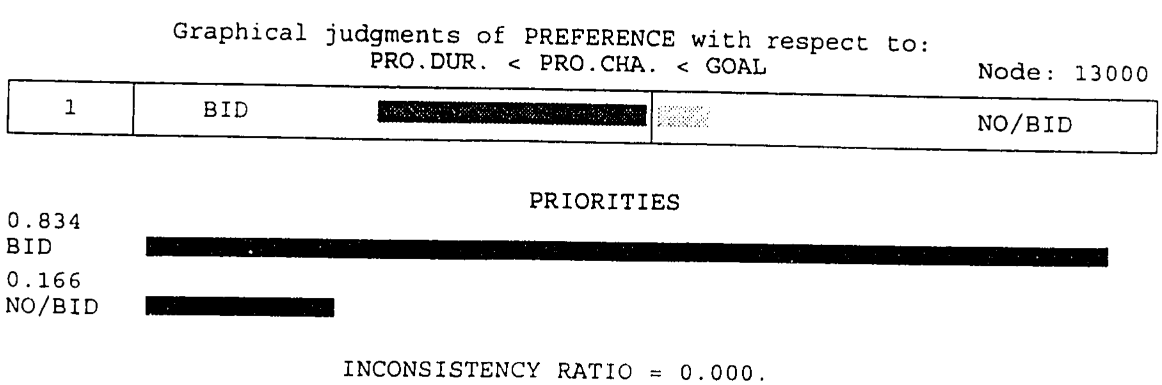


Fig. 13 .4 Judgement & Priorities Of Alternatives with respect

Duration

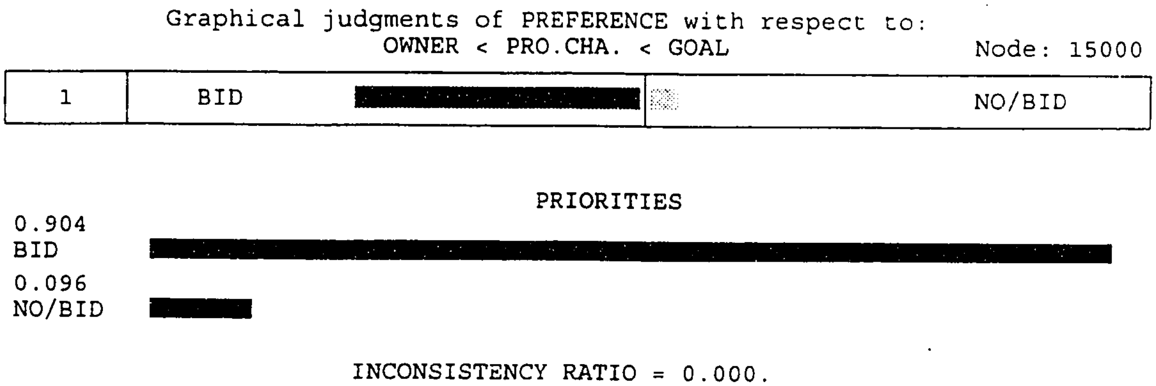


Fig. 13.5 Judgement & Priorities Of Alternatives with respect

Owner

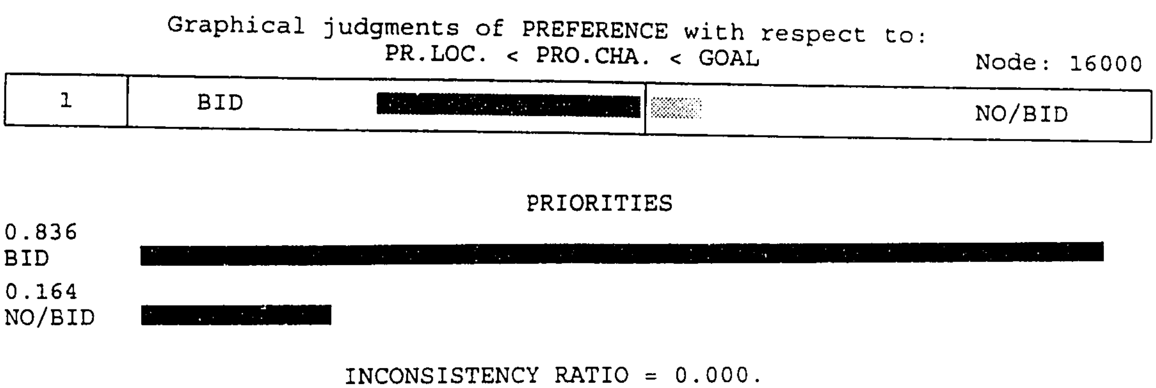


Fig. 13.6 Judgement & Priorities Of Alternatives with respect

Location of Project

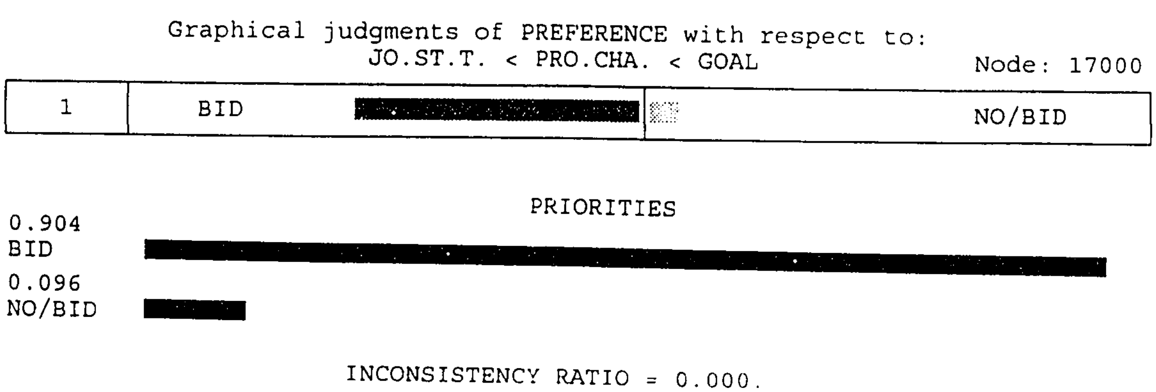


Fig. 13.7 Judgement & Priorities Of Alternatives with respect

Job start time

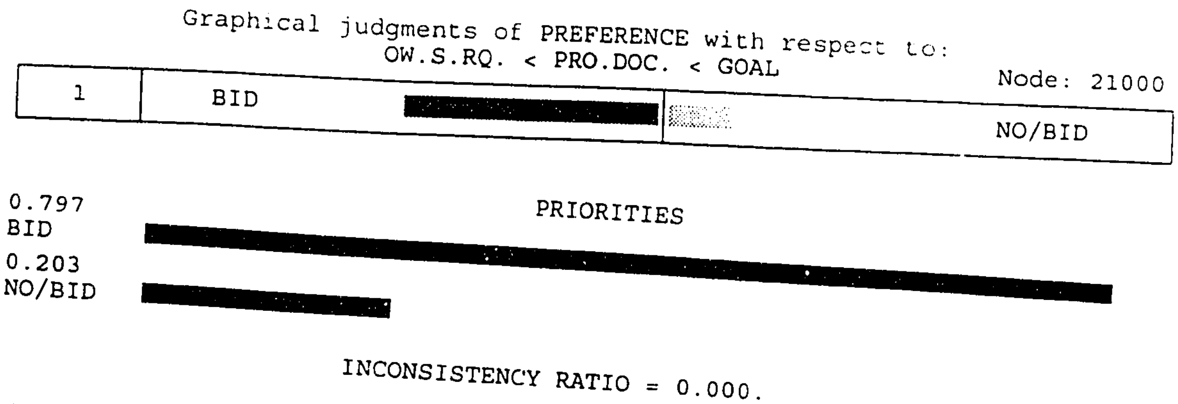


Fig. 13.8 Judgement & Priorities Of Alternatives with respect Owner special requirements

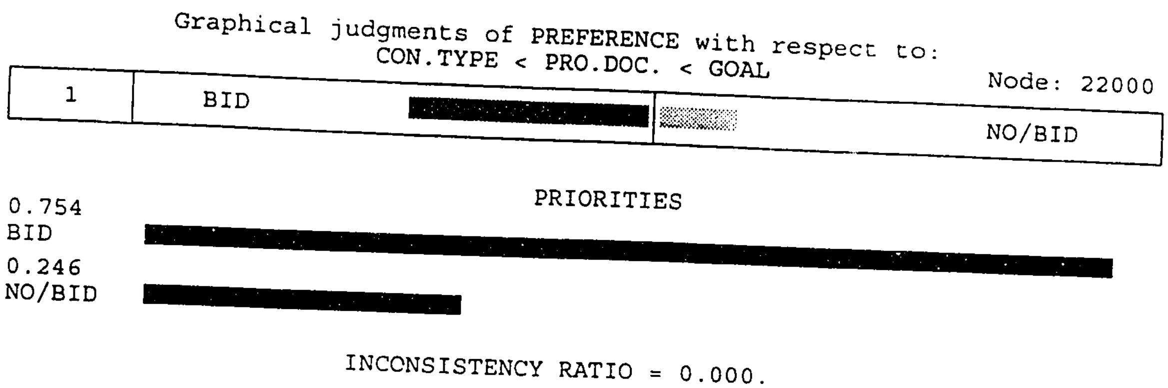


Fig. 13.9 Judgement & Priorities Of Alternatives with respect Type of contract

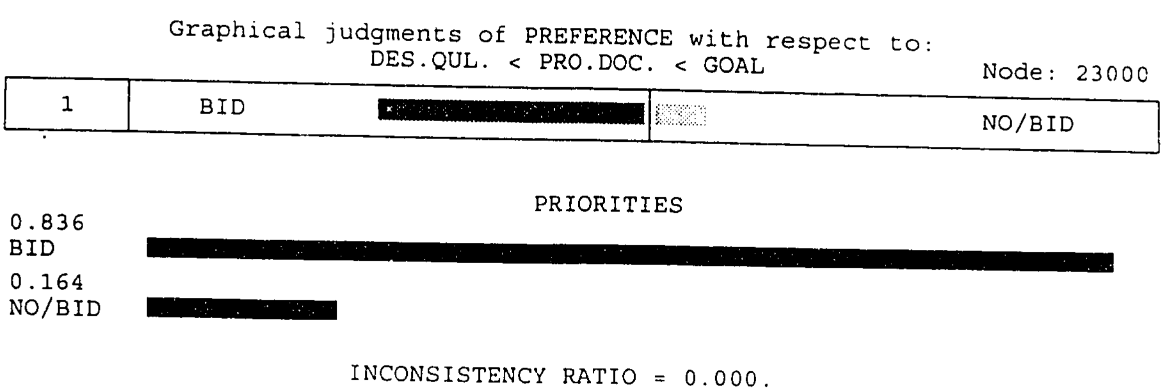


Fig. 13.10 Judgement & Priorities Of Alternatives with respect Design quality

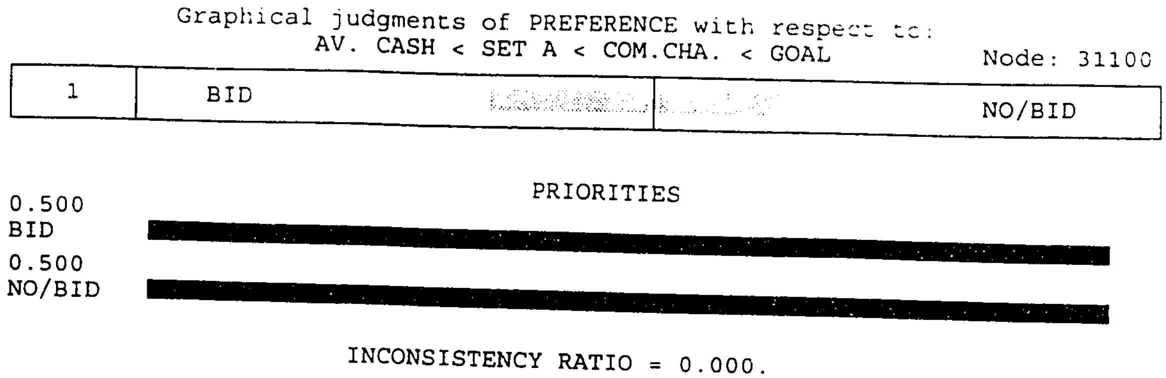


Fig. 13.11 Judgement & Priorities Of Alternatives with respect Availability of required cash

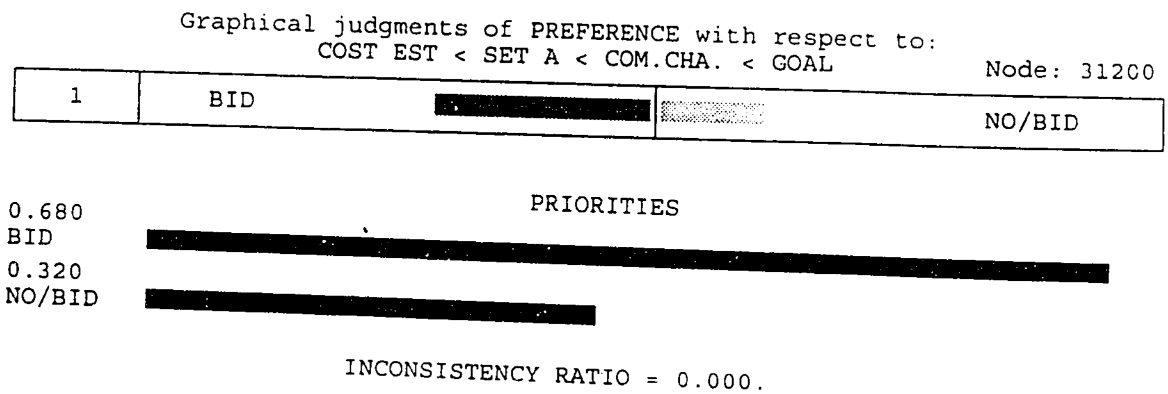


Fig. 13.12 Judgement & Priorities Of Alternatives with respect Uncertainty in cost estimate

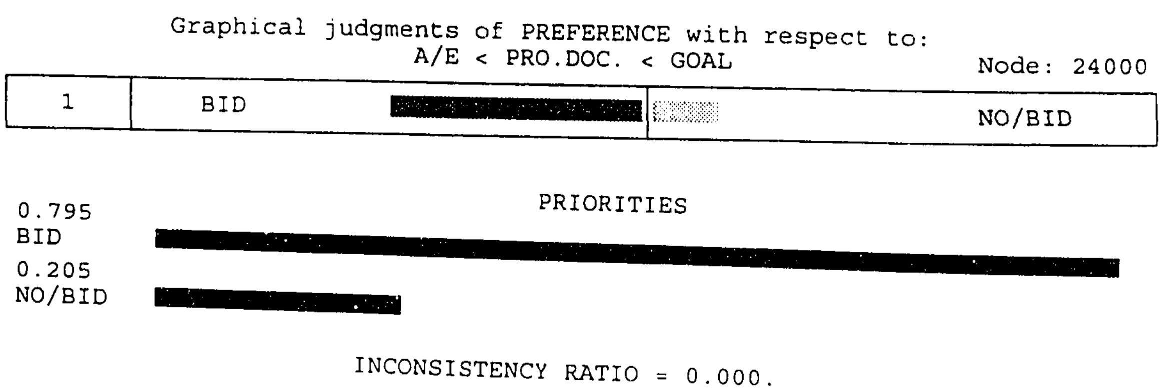


Fig. 13.13 Judgement & Priorities Of Alternatives with respect Designer (A/E)

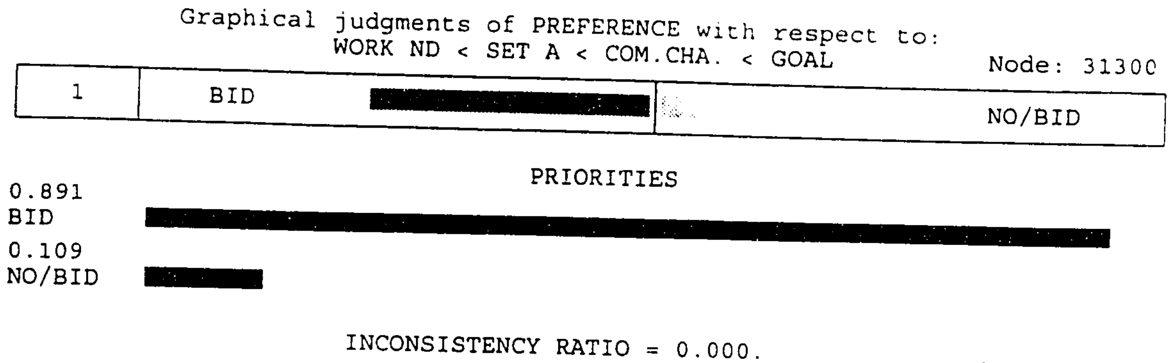


Fig. 13.14 Judgement & Priorities Of Alternatives with respect

Need for work

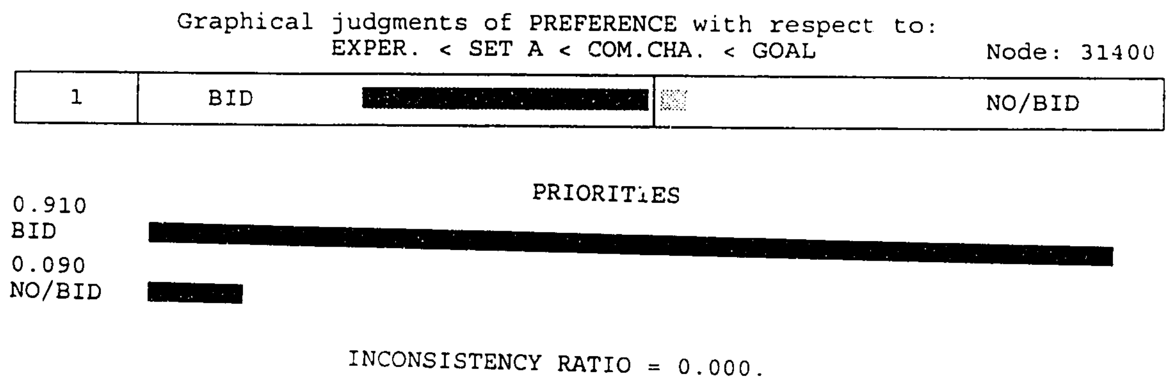


Fig. 13.15 Judgement & Priorities Of Alternatives with respect

Experience in such projects

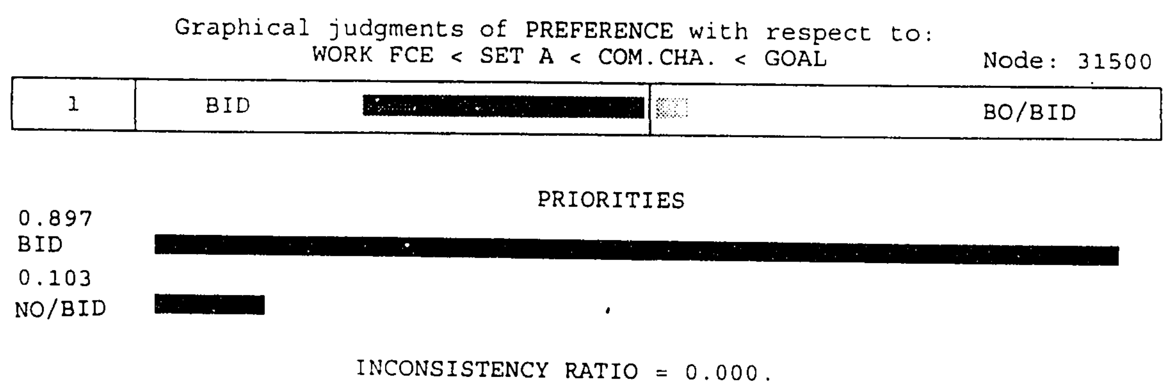


Fig. 13.16 Judgement & Priorities Of Alternatives with respect

Confidence in work force

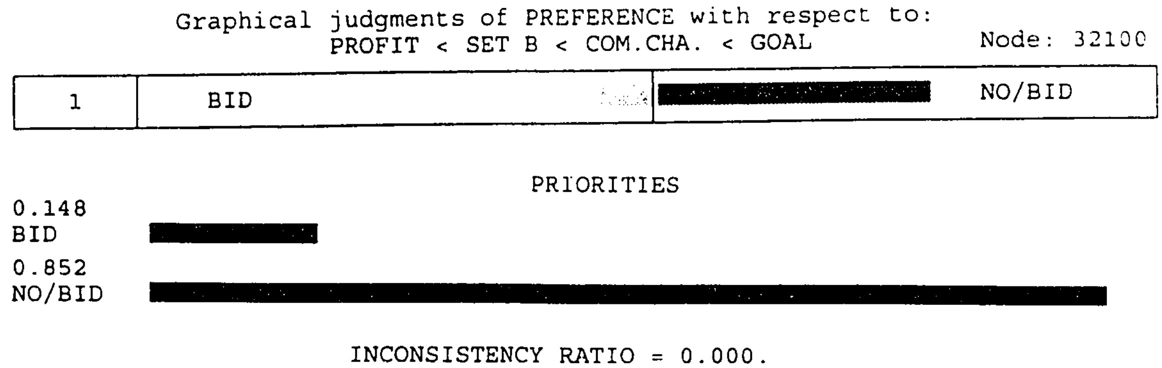


Fig. 13.17 Judgement & Priorities Of Alternatives with respect

Past profit in similar

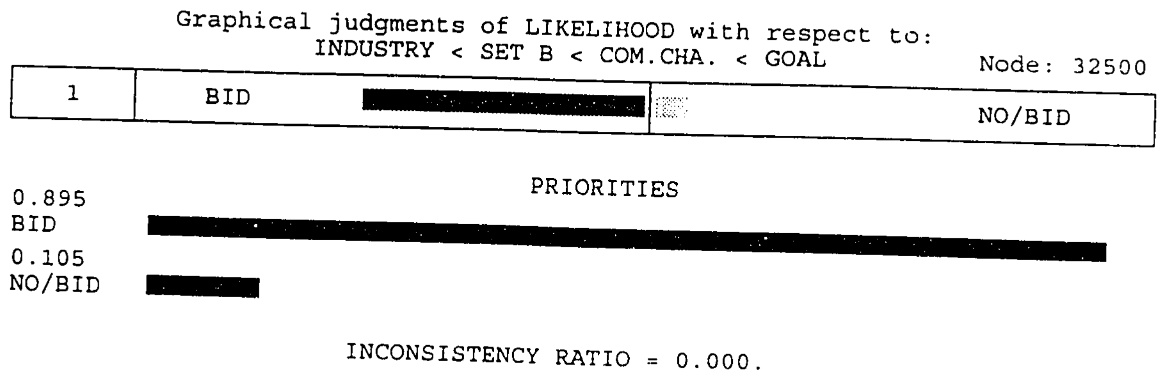


Fig. 13.18 Judgement & Priorities Of Alternatives with respect

Strength in industry

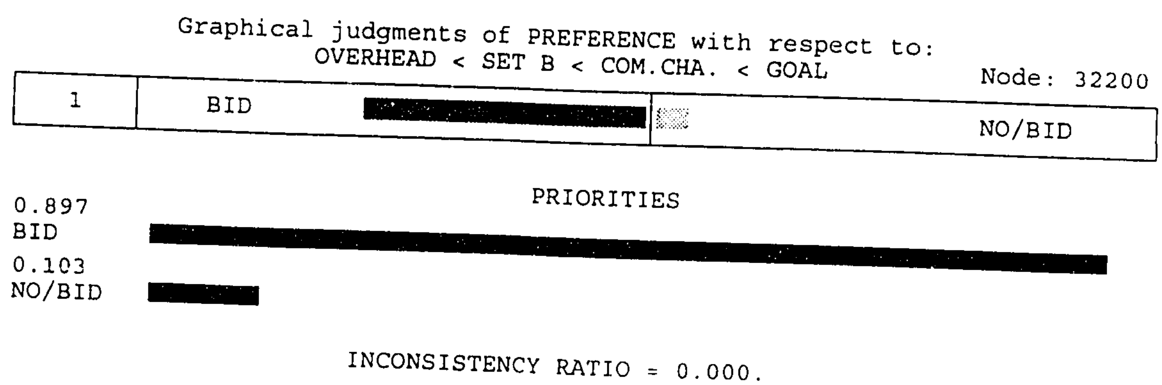


Fig. 13 .19 Judgement & Priorities Of Alternatives with respect

General (office) overhead

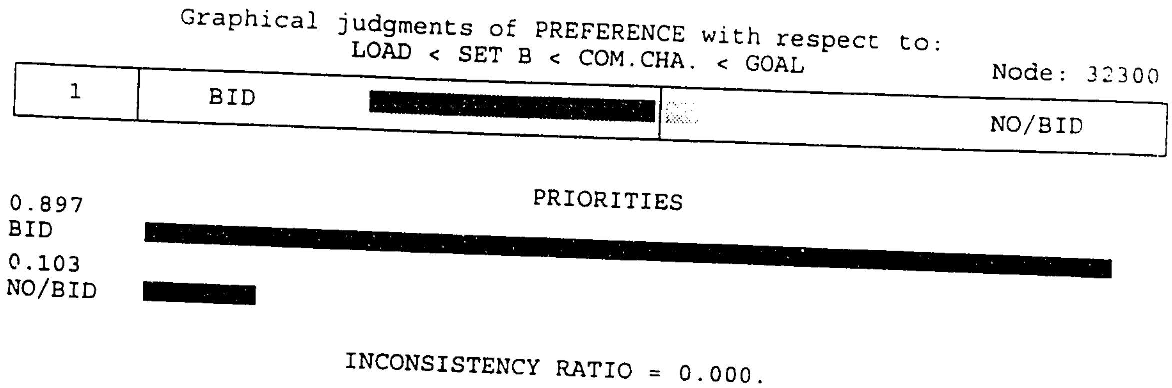


Fig. 13 .20 Judgement & Priorities Of Alternatives with respect Current work load

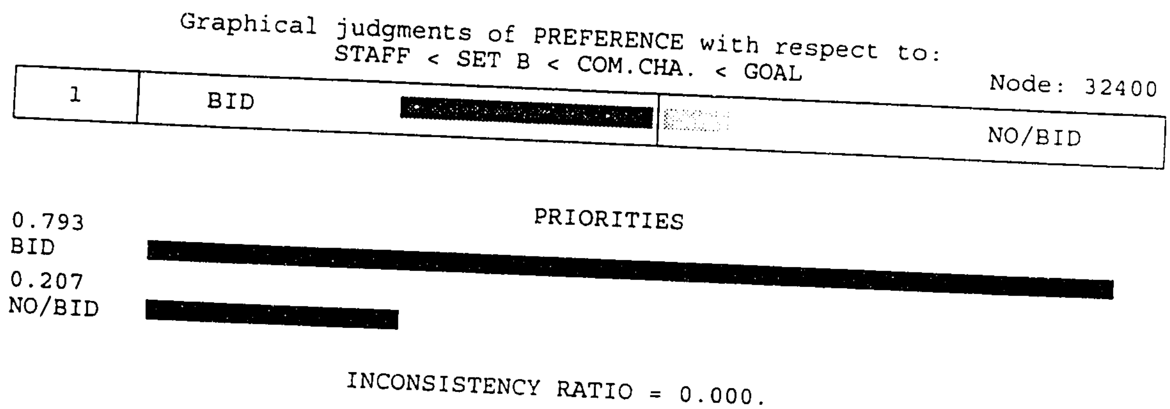


Fig. 13 .21 Judgement & Priorities Of Alternatives with respect Availability of qualified staff

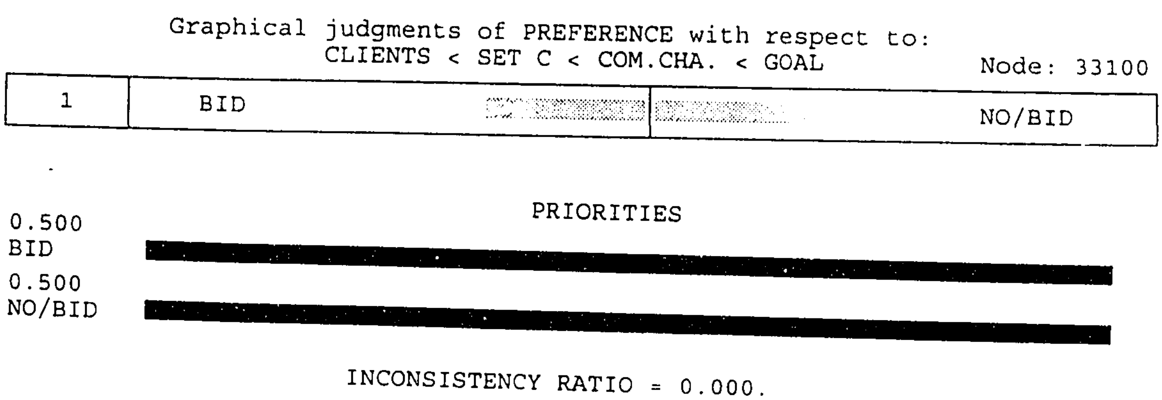


Fig. 13 .22 Judgement & Priorities Of Alternatives with respect Establishing long relation with clients

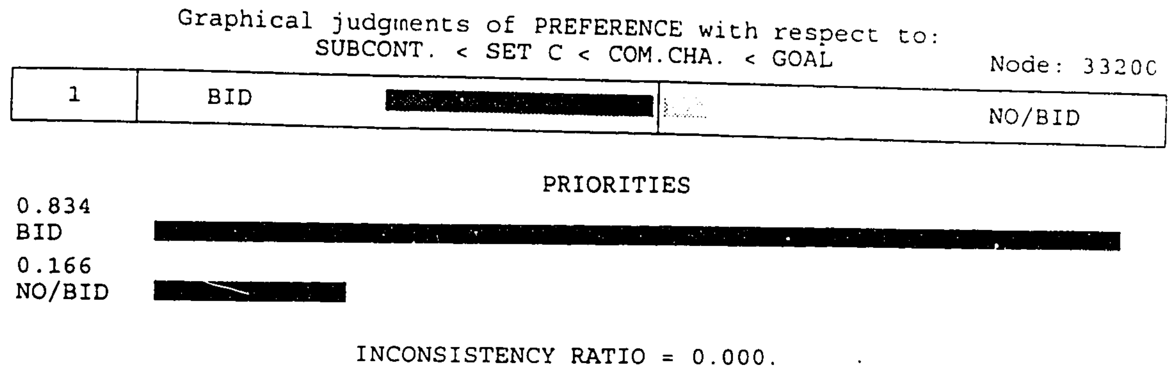


Fig. 13.23 Judgement & Priorities Of Alternatives with respect Reliability of subcontractors

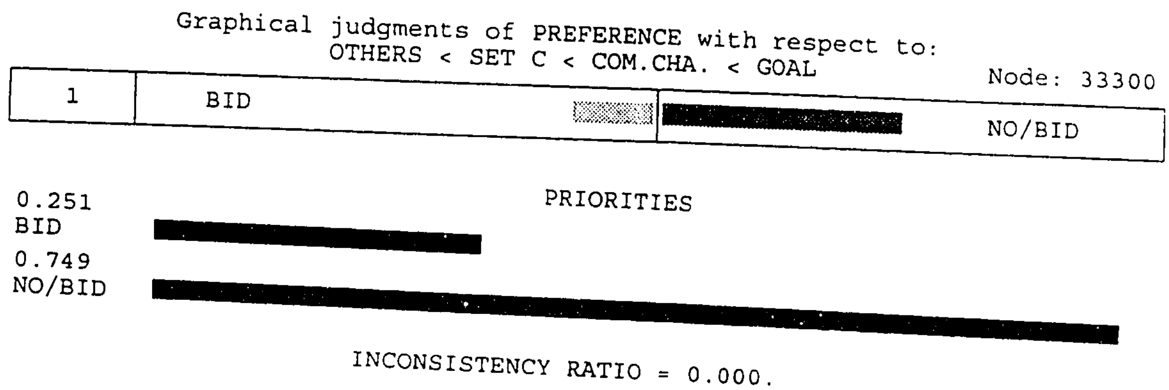


Fig. 13.24 Judgement & Priorities Of Alternatives with respect Portion subcontracted to others

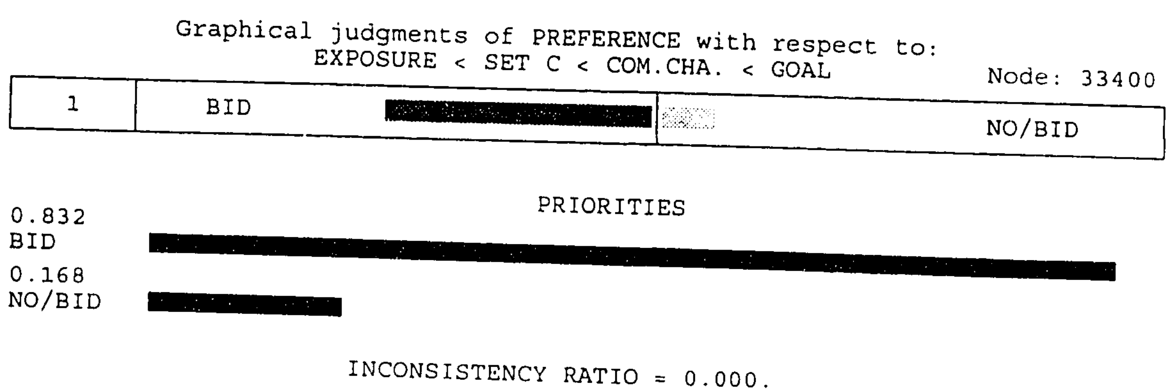


Fig. 13.25 Judgement & Priorities Of Alternatives with respect _Public exposure

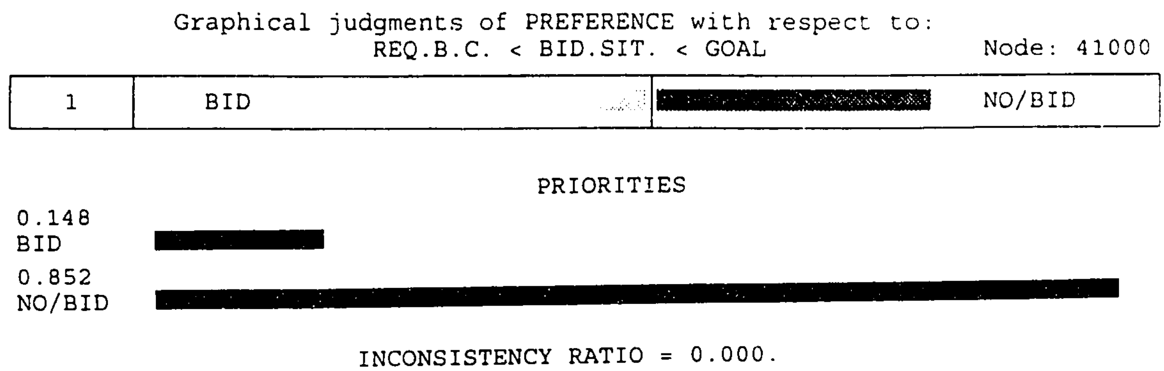


Fig. 13 .26 Judgement & Priorities Of Alternatives with respect Required bond capacity

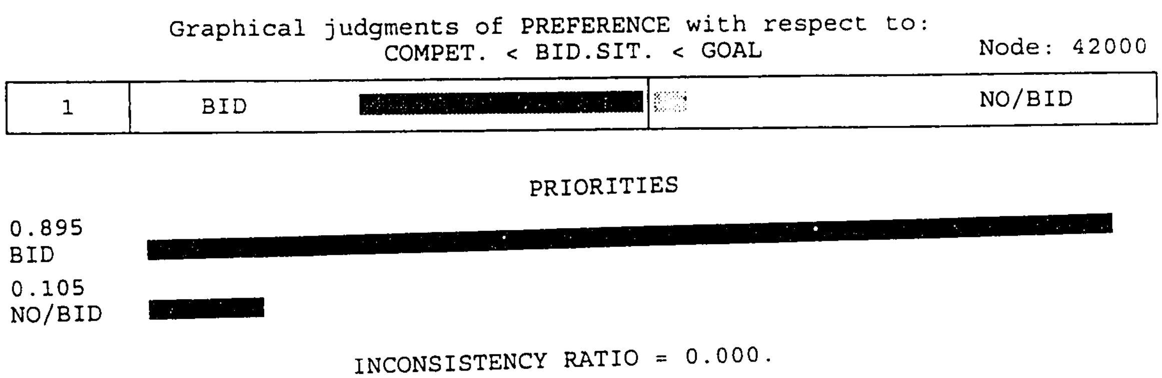


Fig. 13 .27 Judgement & Priorities Of Alternatives with respect Competition

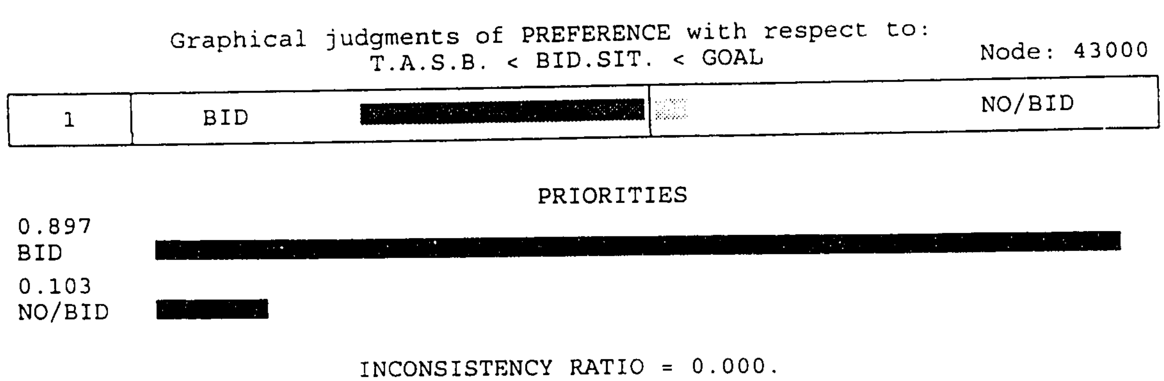


Fig. 13 .28 Judgement & Priorities Of Alternatives with respect Time allowed for submitting bids

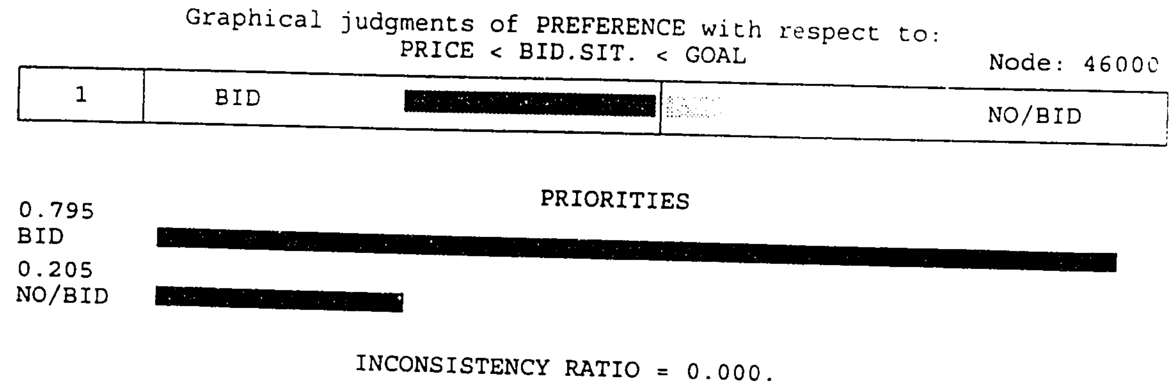


Fig. 13.29 Judgement & Priorities Of Alternatives with respect Bidding document price

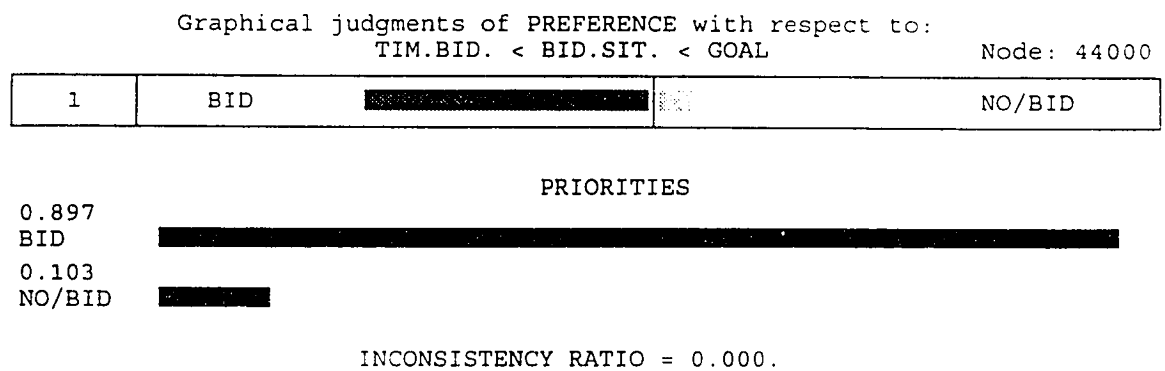


Fig. 13.30 Judgement & Priorities Of Alternatives with respect Time of bidding (season)

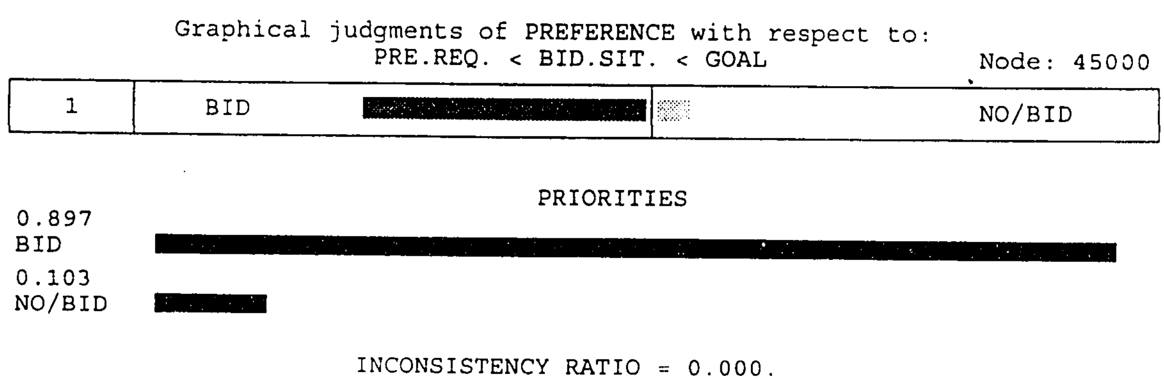


Fig. 13.31 Judgement & Priorities Of Alternatives with respect Prequalification requirements

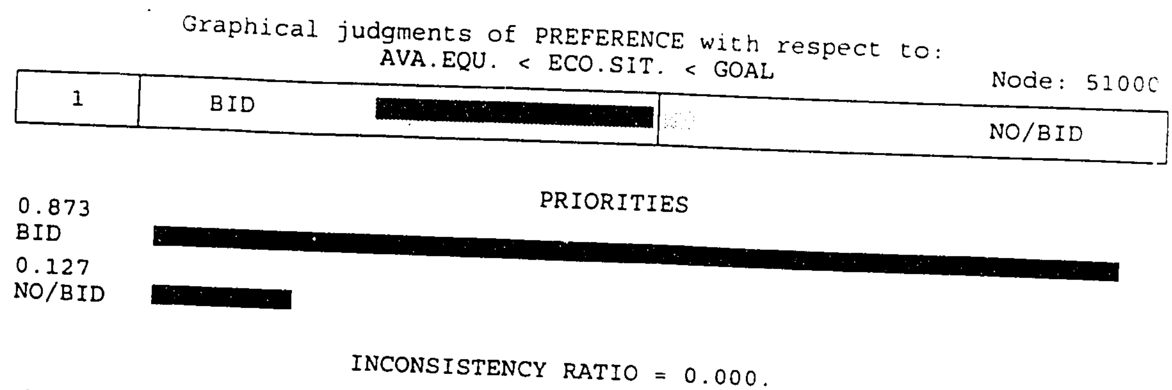


Fig. 13.32 Judgement & Priorities Of Alternatives with respect Availability of equipment

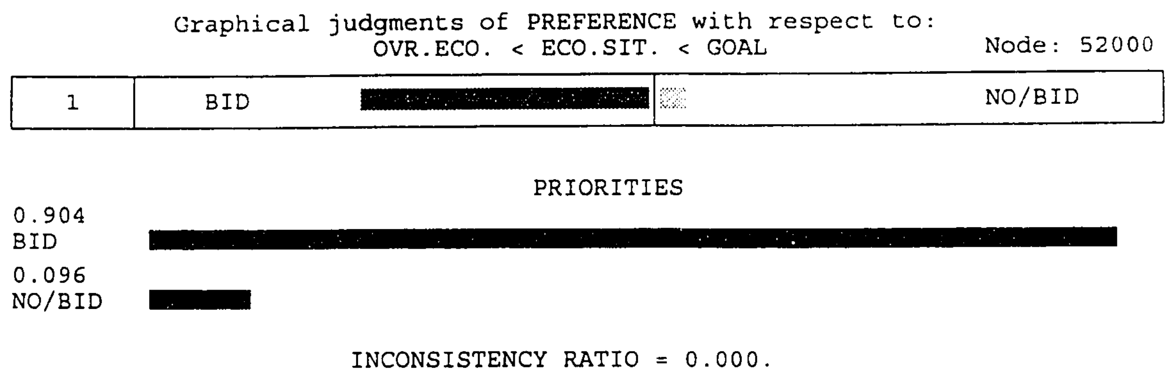


Fig. 13.33 Judgement & Priorities Of Alternatives with respect Overall economy (availability of work)

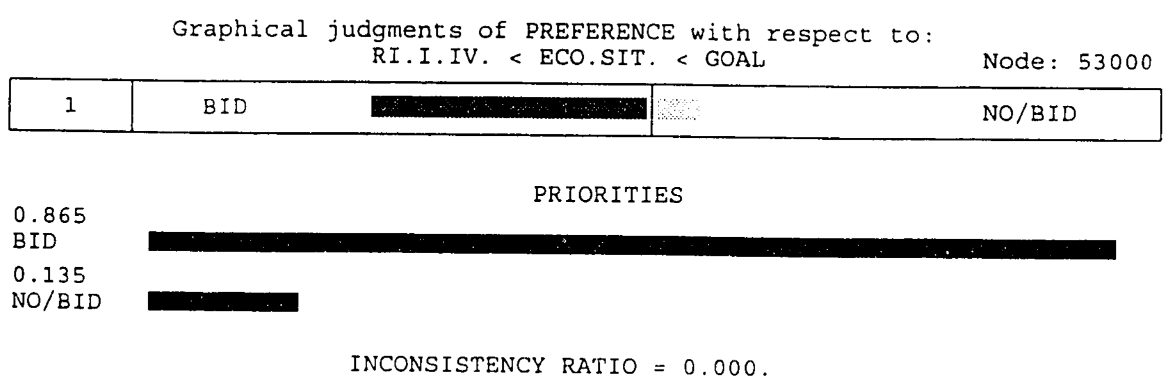


Fig. 13.34 Judgement & Priorities Of Alternatives with respect Risk involved in investment

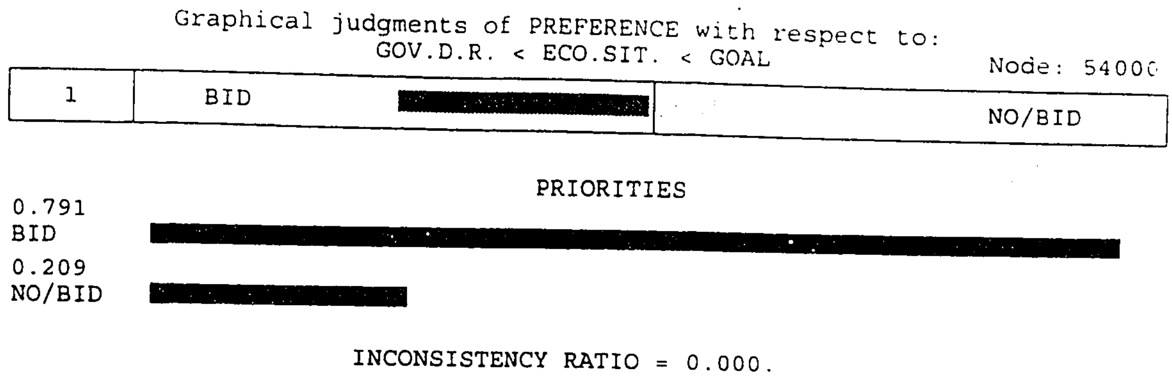


Fig. 13.35 Judgement & Priorities Of Alternatives with respect Governmental division requirements

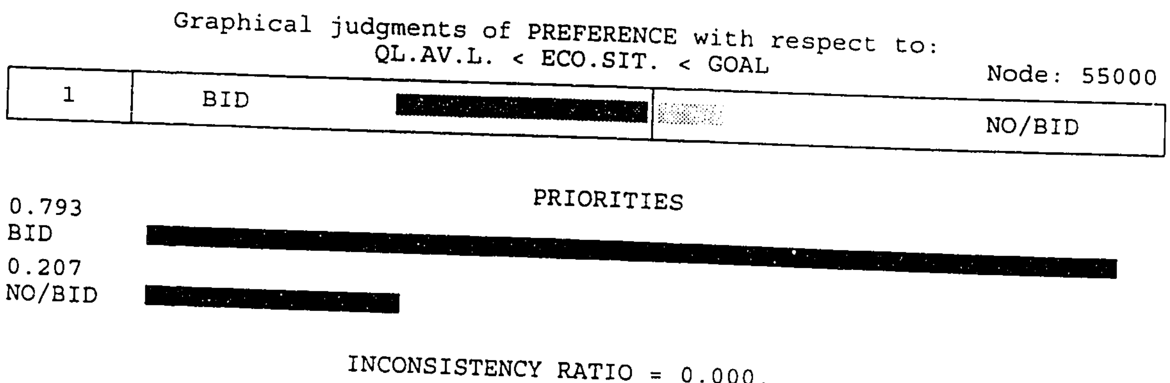


Fig. 13.36 Judgement & Priorities Of Alternatives with respect Quality of available labor

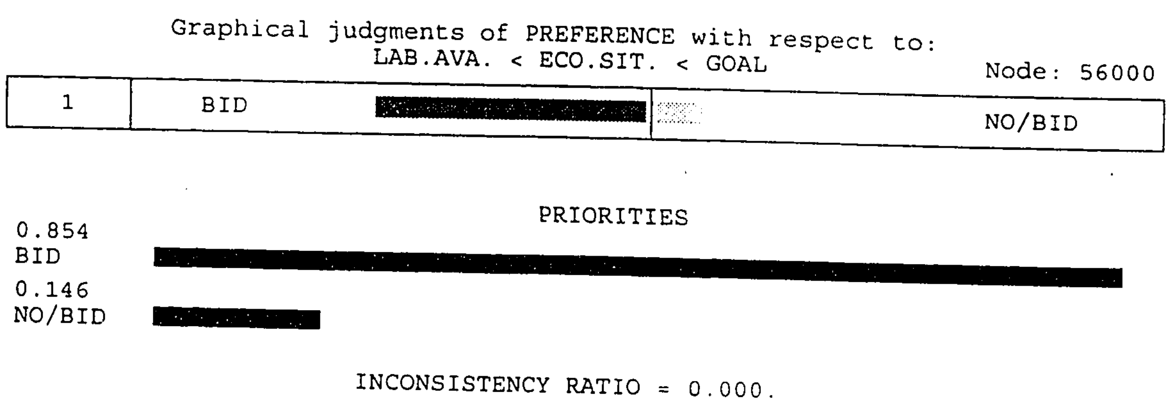


Fig. 13.37 Judgement & Priorities Of Alternatives with respect Availability of labor

Fig. 13: Preference and Priority of Alternatives .

The importance of the factors affecting bidding with respect to their parent nodes in the sub-criteria level was judged by using the Numerical Comparison Mode. For each judgment matrix, Expert Choice displayed the bidding factor priorities and their consistency ratio. In cases where the consistency ratio was greater than 0.1 judgments were re-examined. For the result of judgments and their priorities refer to Figures 14, 15, 16, and 17.

The 14 bidding factors, under the company characteristics node, which had been inserted under the three dummy nodes, were judged as if they were compared together. that was achieved by following the software instructions to go beyond the limit of 7 nodes as follows:

1. Availability of cash flow node was selected from Set A to serve as a link node to Set B, hence there were 6 nodes in Set B (Fig. 18).

2. Availability of cash flow node was selected again from Set A to serve as a link node to Set C, hence there were 5 nodes in C (Fig. 19).

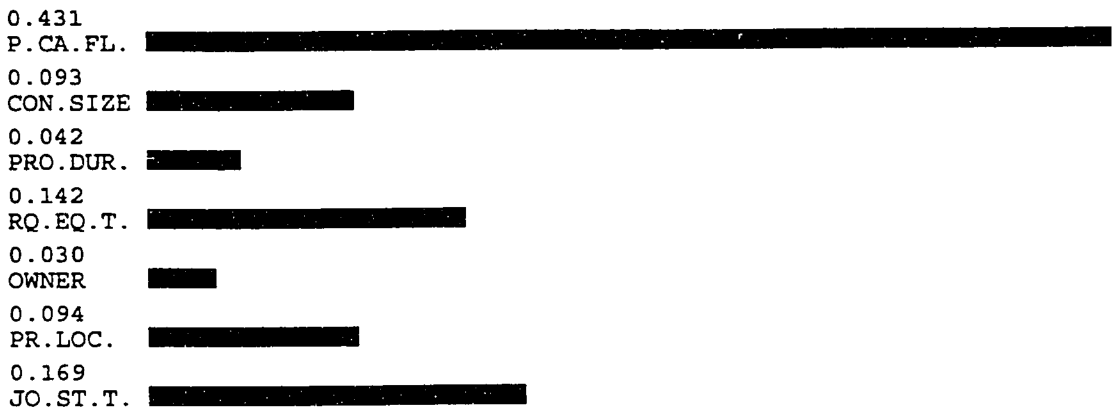
3. The global weights of set A, Set B and Set C were adjusted so that the nodes under them would get equal starting weights, and was executed as follows:

From the parent node of Set A, Set B, and Set C, the Compare, Data Command was used to enter 5 for Set A's 5 nodes, 6 for Set B's 6 nodes and 5 for Set C's nodes (Fig. 20).

JUDGMENTS WITH RESPECT TO
PRO.CHA. < GOAL

	P.CA.FL.	CON.SIZE	PRO.DUR.	RQ.EQ.T.	OWNER	PR.LOC.	JO.ST.T.
P.CA.FL.		7.0	7.0	5.0	5.0	3.0	5.0
CON.SIZE			3.0	1.0	5.0	1.0	(3.0)
PRO.DUR.				(3.0)	3.0	(5.0)	(5.0)
RQ.EQ.T.					7.0	3.0	1.0
OWNER						(3.0)	(5.0)
PR.LOC.							(3.0)
JO.ST.T.							

PRIORITIES



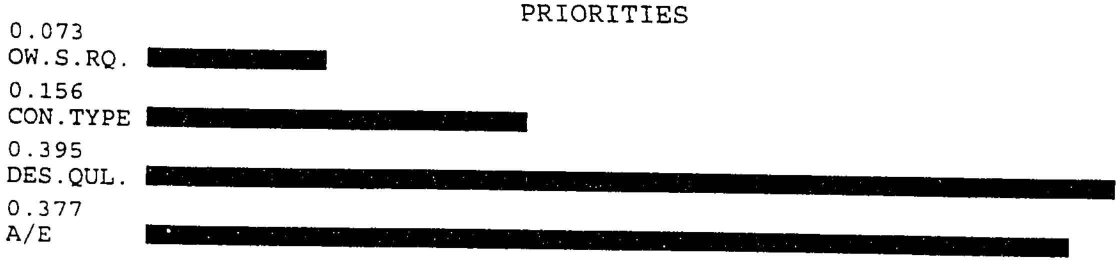
INCONSISTENCY RATIO = 0.098.

Fig. 14: Importance and Priority of Bidding Factors with Respect Project Characteristics

JUDGMENTS WITH RESPECT TO
PRO.DOC. < GOAL

	OW.S.RQ.	CON.TYPE	DES.QUL.	A/E
OW.S.RQ.		(3.0)	(5.0)	(4.0)
CON.TYPE			(3.0)	(3.0)
DES.QUL.				1.0
A/E				

PRIORITIES

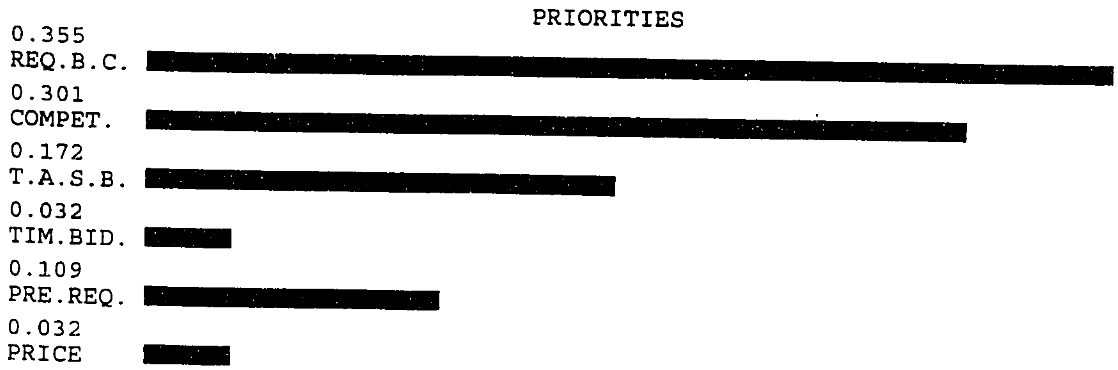


INCONSISTENCY RATIO = 0.025.

Fig. 15: Importance and Priority of Bidding Factors with Respect Project Documents.

JUDGMENTS WITH RESPECT TO
BID.SIT. < GOAL

	REQ.B.C.	COMPET.	T.A.S.B.	TIM.BID.	PRE.REQ.	PRICE
REQ.B.C.		1.0	5.0	7.0	3.0	7.0
COMPET.			3.0	7.0	3.0	7.0
T.A.S.B.				7.0	3.0	7.0
TIM.BID.					(5.0)	1.0
PRE.REQ.						5.0
PRICE						

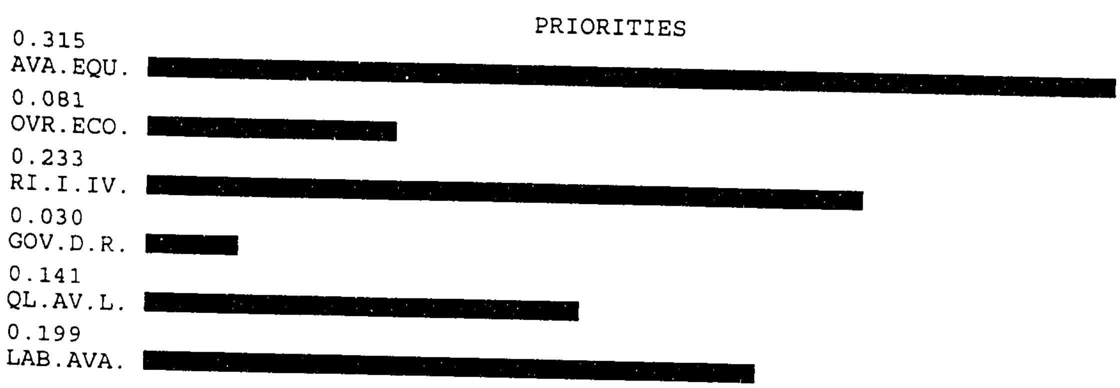


INCONSISTENCY RATIO = 0.071.

Fig. 16: Importance and Priority of Bidding Factors with Respect Bidding Situation .

JUDGMENTS WITH RESPECT TO
ECO.SIT. < GOAL

	AVA.EQU.	OVR.ECO.	RI.I.IV.	GOV.D.R.	QL.AV.L.	LAB.AVA.
AVA.EQU.		8.0	1.0	7.0	3.0	1.0
OVR.ECO.			(5.0)	5.0	1.0	(3.0)
RI.I.IV.				7.0	1.0	1.0
GOV.D.R.					(5.0)	(5.0)
QL.AV.L.						1.0
LAB.AVA.						



INCONSISTENCY RATIO = 0.071.

Fig. 17: Importance and Priority of Bidding Factors with Respect Economic Situation .

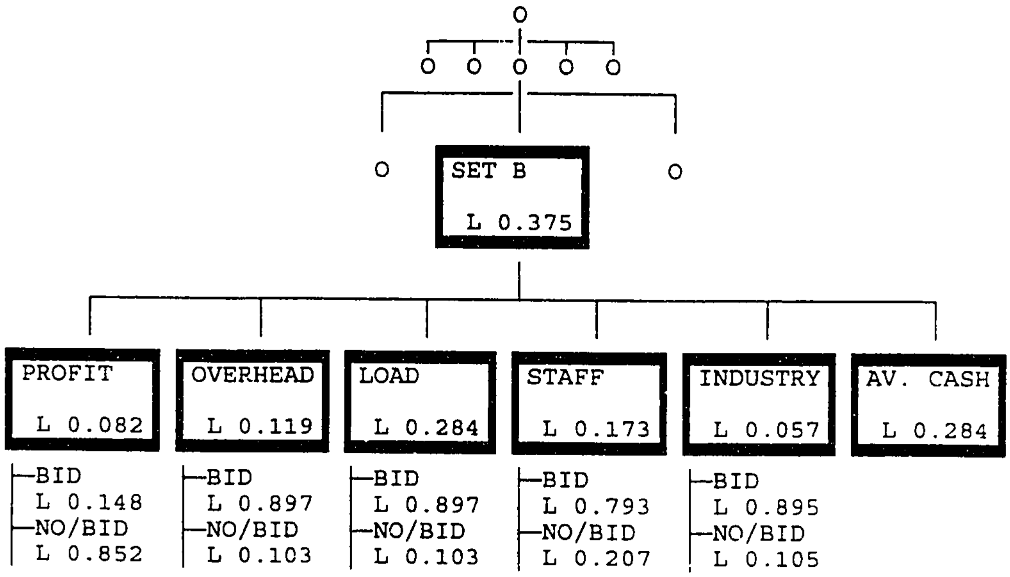


Fig. 18: Set B with the Link Node .

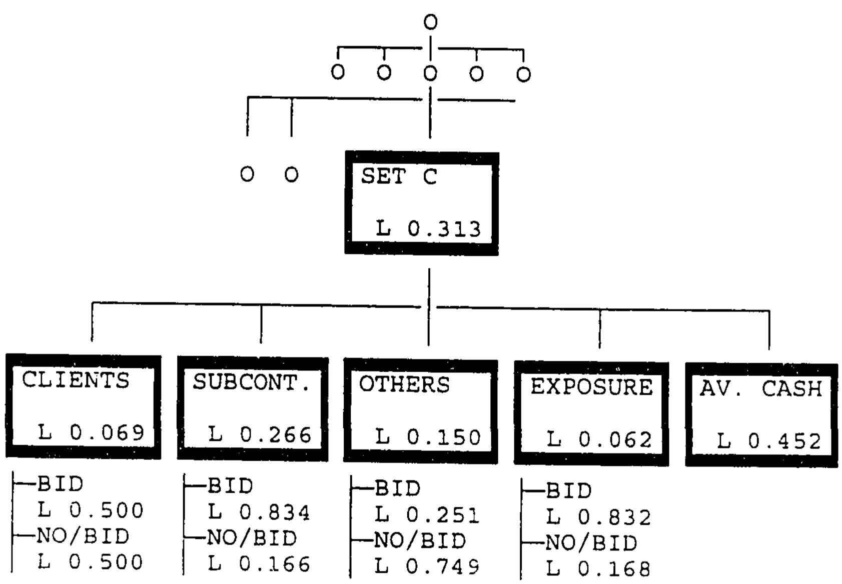


Fig. 19: Set C with the Link Node .

Data with respect to:
COM.CHA. < GOAL

	VALUE
SET A	5.00000
SET B	6.00000
SET C	5.00000

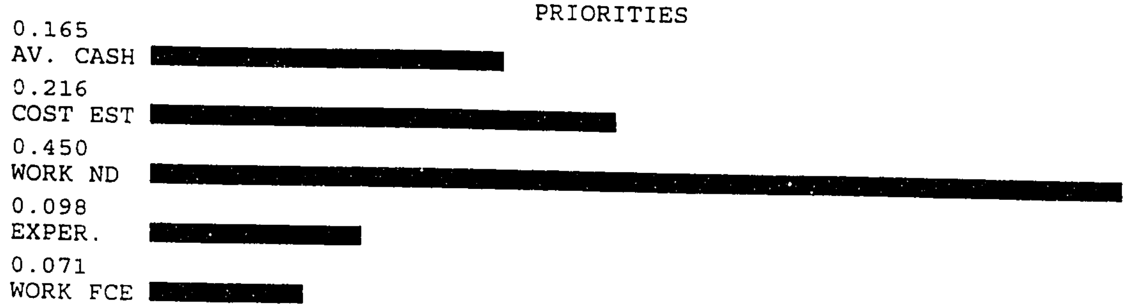
Fig. 20: Compare, Data Screen Showing Values Entered for Set A, set B, and Set C .

4. The Numerical Comparison Mode was use to pair-wise compare the nodes of Set A, Set B and set C. Judgements and the resulting priorities for the nodes of Set A, Set B, and Set C were shown in Figures. 21, 22, and 23 respectively.

JUDGMENTS WITH RESPECT TO
SET A < COM.CHA. < GOAL

	AV. CASH	COST EST	WORK ND	EXPER.	WORK FCE
AV. CASH		(3.0)	(3.0)	3.0	3.0
COST EST			(3.0)	1.0	3.0
WORK ND				5.0	5.0
EXPER.					1.0
WORK FCE					

PRIORITIES

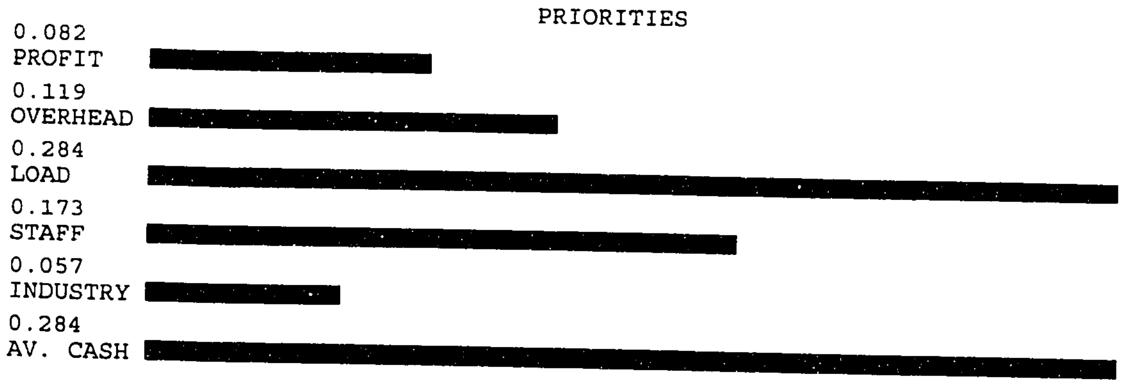


INCONSISTENCY RATIO = 0.095.

Fig. 21: Judgements and Priorities of Set A Nodes .

JUDGMENTS WITH RESPECT TO
SET B < COM.CHA. < GOAL

	PROFIT	OVERHEAD	LOAD	STAFF	INDUSTRY	AV. CASH
PROFIT		(3.0)	(3.0)	(3.0)	3.0	(3.0)
OVERHEAD			(3.0)	(3.0)	3.0	(3.0)
LOAD				3.0	3.0	1.0
STAFF					3.0	(3.0)
INDUSTRY						(3.0)
AV. CASH						



INCONSISTENCY RATIO = 0.089.

Fig. 22: Judgements and Priorities of Set B Nodes (with the link node)

weight of link node in Set A = 0.165

weight of link node in Set B = 0.284

multiplication factor = 0.165/0.284 =0.58099

unifying the weight of the link node in the two nodes give the following new global weights for Set Bs nodes:

profit =0.0476 ,overhead = 0.0691 , load = 0.165

staff = 0.1005 ,industry =0.0331

JUDGMENTS WITH RESPECT TO
SET C < COM.CHA. < GOAL

	CLIENTS	SUBCONT.	OTHERS	EXPOSURE	AV. CASH
CLIENTS		(3.0)	(3.0)	1.0	(5.0)
SUBCONT.			3.0	5.0	(3.0)
OTHERS				3.0	(3.0)
EXPOSURE					(5.0)
AV. CASH					

PRIORITIES

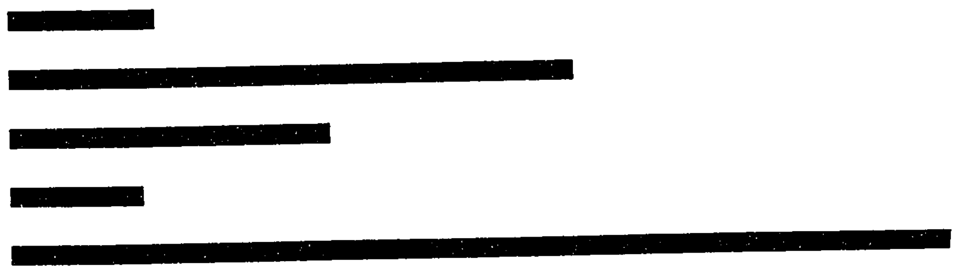
0.069
CLIENTS

0.266
SUBCONT.

0.150
OTHERS

0.062
EXPOSURE

0.452
AV. CASH



INCONSISTENCY RATIO = 0.049.

Fig. 23: Judgements and Priorities of Set C Nodes (with the link node)

weight of link node in Set A = 0.165

weight of link node in Set C = 0.452

multiplication factor = 0.165/0.452 =0.36504

unifying the weight of the link node in the two nodes give the following new global weights for Set Cs nodes : clients =0.0252 ,subcontract= 0.0971 , others = 0.0548 , exposure = 0.0226

5. The global weights of Set B nodes were multiplied by the global weight of the linking node in Set A and divided by the global weight of the linking node in Set B. By this process, the linking factor between Set A and Set B would have a unified global weight in the two sets. For the new weights of Set B nodes refer to Figure 22.

6. The global weights of Set C nodes were multiplied by the global weight of the linking node in Set A and again divided by the global weight of the linking node in Set C. By this process The linking factor between Set A and Set C would had a unified global weight. For the new weights of Set C nodes refer to Figure 23.

7. The linking node between Set A and Set B was deleted from Set B, The linking node between Set A and Set C was deleted from Set C.

8. Set B node was highlighted, and Compare, Data Command was used to enter the new global weights of its nodes (Fig. 24). The same step was repeated for Set C (Fig. 25). The above steps were essential to re-normalize the total weights of the Set B and Set C nodes.

9. The Company Characteristics node was highlighted, and Compare, Data Command was used to normalize the global weights of Set A, Set B, and Set C as follows:

Since no weights were changed in Set A then 0.3130 was entered as its weight, 0.4153 was entered as the new global weight for Set B, and 0.1997 was entered as the new global weight for Set C (Fig. 26). As a result, the

Data with respect to:
SET B < COM.CHA. < GOAL

	VALUE
PROFIT	0.04760
OVERHEAD	0.06910
LOAD	0.16500
STAFF	0.10050
INDUSTRY	0.03310

Fig. 24: Compare, Data screen Showing the New Weights entered for Set B Nodes .

Data with respect to:
SET C < COM.CHA. < GOAL

	VALUE
CLIENTS	0.02520
SUBCONT.	0.09710
OTHERS	0.05480
EXPOSURE	0.02260

Fig. 25: Compare, Data screen Showing the New Weights entered for Set C Nodes .

With respect to
COM.CHA. < GOAL

	VALUE
SET A	0.31300
SET B	0.41530
SET C	0.19970

Fig. 26: Compare, Data screen Showing the New Weights entered for Company Characteristics Node.

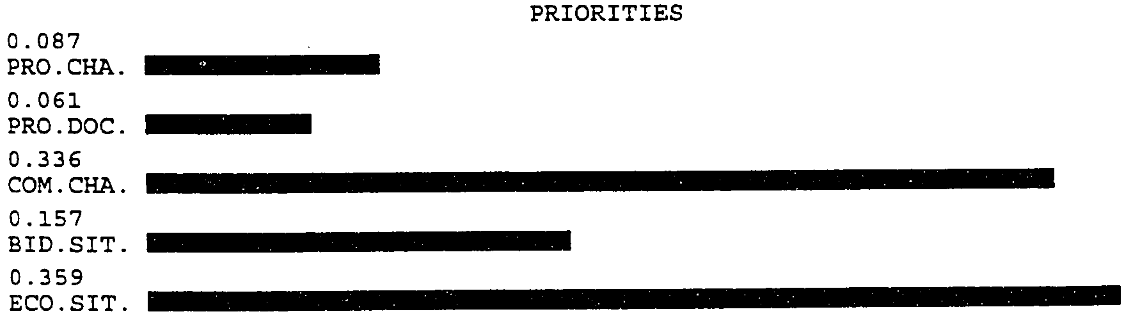
global weights of the 14 factors across the three sets would look as if they were a single set.

Finally the Numerical Comparison Mode was used to compare the importance of the model's main criteria with respect the goal (Fig. 27).

JUDGMENTS WITH RESPECT TO
GOAL

	PRO.CHA.	PRO.DOC.	COM.CHA.	BID.SIT.	ECO.SIT.
PRO.CHA.		3.0	(5.0)	(3.0)	(5.0)
PRO.DOC.			(3.0)	(3.0)	(5.0)
COM.CHA.				3.0	1.0
BID.SIT.					(3.0)
ECO.SIT.					

PRIORITIES



INCONSISTENCY RATIO = 0.071.

Fig. 27 : Judegments and Priorities of Model's Main Criteria with respect to Goal .

4.2.4 Synthesing to get results

When judgements throughout the model were done, the Distributive Mode was selected to perform synthesis from the goal. Synthesis process converted all the local priorities into global priorities throughout the model and gave the global weight of the alternatives. As a result, the Bid alternative got priority of 75% and No/bid alternative with a priority of 25% (Fig. 28), with an overall consistency index of 0.06. Details of the synthesis were shown in Figure 29. The contractors decision maker accepted the result and wanted to examine the sensitivity of alternatives to change in priority of the model's main criteria with respect to the goal.

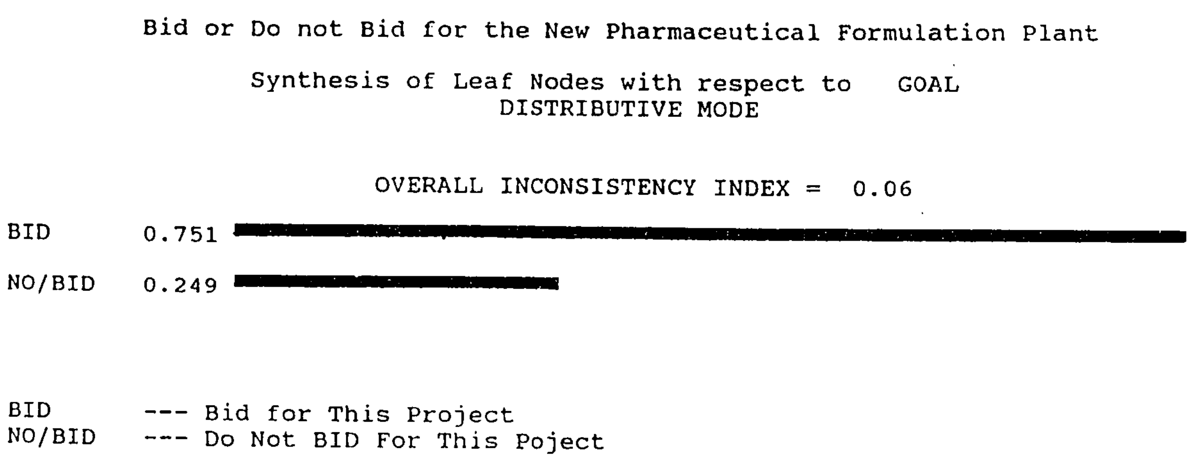


Fig. 28: Priority of Alternatives with respect Goal.

Bid or Do not Bid for the New Pharmaceutical Formulation Plant
Sorted Details for Synthesis of Leaf Nodes with respect to GOAL
DISTRIBUTIVE MODE

LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4	LEVEL 5
ECO.SIT. =0.359				
	AVA.EQU. =0.113			
		BID =0.099		
		NO/BID =0.014		
	RI.I.IV. =0.084			
		BID =0.073		
		NO/BID =0.011		
	LAB.AVA. =0.071			
		BID =0.061		
		NO/BID =0.010		
	QL.AV.L. =0.051			
		BID =0.040		
		NO/BID =0.010		
	OVR.ECO. =0.029			
		BID =0.026		
		NO/BID =0.003		
	GOV.D.R. =0.011			
		BID =0.008		
		NO/BID =0.002		
COM.CHA. =0.336				
	SET B =0.157			
		LOAD =0.062		
			BID =0.056	
			NO/BID =0.006	
		STAFF =0.038		
			BID =0.030	
			NO/BID =0.008	
		OVERHEAD =0.026		
			BID =0.023	
			NO/BID =0.003	
		PROFIT =0.018		
			NO/BID =0.015	
			BID =0.003	
		INDUSTRY =0.013		
			BID =0.011	
			NO/BID =0.001	
	SET A =0.109			
		WORK ND =0.049		
			BID =0.044	
			NO/BID =0.005	
		COST EST =0.024		
			BID =0.016	
			NO/BID =0.008	
		AV. CASH =0.018		
			BID =0.009	
			NO/BID =0.009	
		EXPER. =0.011		
			BID =0.010	
			NO/BID .96E-03	
		WORK FCE =0.008		
			BID =0.007	
			NO/BID .80E-03	
	SET C =0.070			
		SUBCONT. =0.034		
			BID =0.028	
			NO/BID =0.006	
		OTHERS =0.019		
			NO/BID =0.014	
			BID =0.005	
		CLIENTS =0.009		
			BID =0.004	
			NO/BID =0.004	
		EXPOSURE =0.008		
			BID =0.007	
			NO/BID =0.001	

Bid or Do not Bid for the New Pharmaceutical Formulation Plant
Sorted Details for Synthesis of Leaf Nodes with respect to GOAL
DISTRIBUTIVE MODE

LEVEL 1	LEVEL 2	LEVEL 3		LEVEL 4	LEVEL 5
BID.SIT. =0.157					
.	REQ.B.C. =0.056				
.	.	NO/BID	=0.047		
.	.	BID	=0.008		
.	COMPET. =0.047				
.	.	BID	=0.042		
.	.	NO/BID	=0.005		
.	T.A.S.B. =0.027				
.	.	BID	=0.024		
.	.	NO/BID	=0.003		
.	PRE.REQ. =0.017				
.	.	BID	=0.015		
.	.	NO/BID	=0.002		
.	TIM.BID. =0.005				
.	.	BID	=0.004		
.	.	NO/BID	.51E-03		
.	PRICE =0.005				
.	.	BID	=0.004		
.	.	NO/BID	=0.001		
PRO.CHA. =0.087					
.	P.CA.FL. =0.037				
.	.	NO/BID	=0.033		
.	.	BID	=0.005		
.	JO.ST.T. =0.015				
.	.	BID	=0.013		
.	.	NO/BID	=0.001		
.	RQ.EQ.T. =0.012				
.	.	BID	=0.011		
.	.	NO/BID	=0.001		
.	PR.LOC. =0.008				
.	.	BID	=0.007		
.	.	NO/BID	=0.001		
.	CON.SIZE =0.008				
.	.	NO/BID	=0.007		
.	.	BID	=0.001		
.	PRO.DUR. =0.004				
.	.	BID	=0.003		
.	.	NO/BID	.60E-03		
.	OWNER =0.003				
.	.	BID	=0.002		
.	.	NO/BID	.25E-03		
PRO.DOC. =0.061					
.	DES.QUL. =0.024				
.	.	BID	=0.020		
.	.	NO/BID	=0.004		
.	A/E =0.023				
.	.	BID	=0.018		
.	.	NO/BID	=0.005		
.	CON.TYPE =0.010				
.	.	BID	=0.007		
.	.	NO/BID	=0.002		
.	OW.S.RQ. =0.005				
.	.	BID	=0.004		
.	.	NO/BID	.91E-03		

FIG. 29: Synthesizing Result .

4.2.5 Sensitivity Analysis

The software's four Graphical Sensitivity Modes were used to investigate from the goal, the sensitivity of alternatives to changes in the priorities of main criteria in level 1 of the model, namely: project characteristics, project documents, company characteristics, bidding situation, and economic situation.

4.2.5.1 Dynamic Sensitivity

The priorities of the model's main criteria were changed one at a time with respect to goal as follows:

1. The priority of project characteristics was changed from 0.087 to 0.242 (Fig. 30.1). As a result, the priority of bid alternative changed from 0.751 to 0.706 and the priority of no-bid alternative changed from 0.249 to 0.294.

2. The priority of the project documents was changed from 0.061 to 0.36 (Fig. 30.2). As a result, the priority of bid alternative changed from 0.751 to 0.768 and the priority of no-bid alternative changed from 0.249 to 0.232.

3. The priority of company characteristics was changed from 0.336 to 0.64 (Fig. 30.3). As a result, the priority of bid alternative changed from 0.751 to 0.752 and the priority of no-bid alternative changed from 0.249 to 0.248.

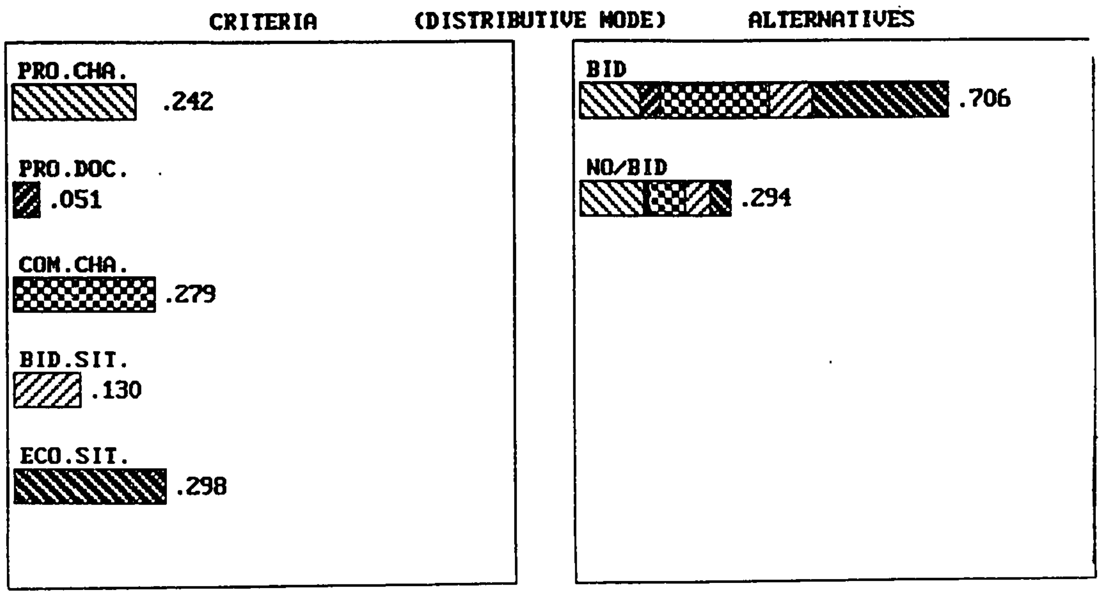


Fig. 30.1: Change in Alternatives Priority due to change in project characteristics priority .

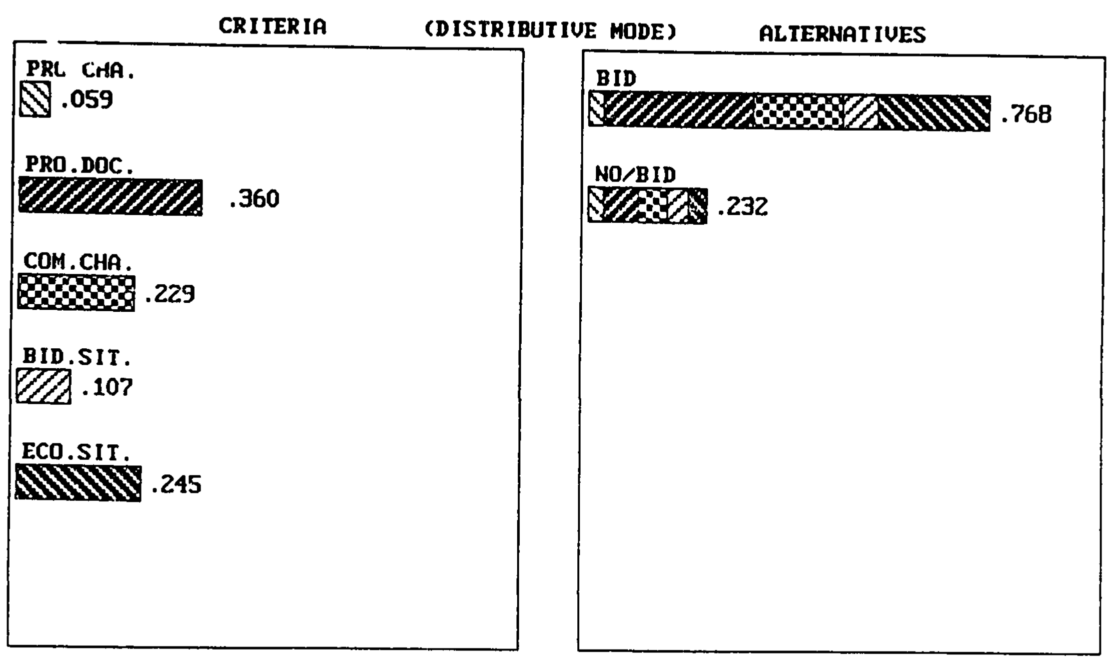


Fig. 30.2 : Change in Alternatives Priority due to change in project documents .

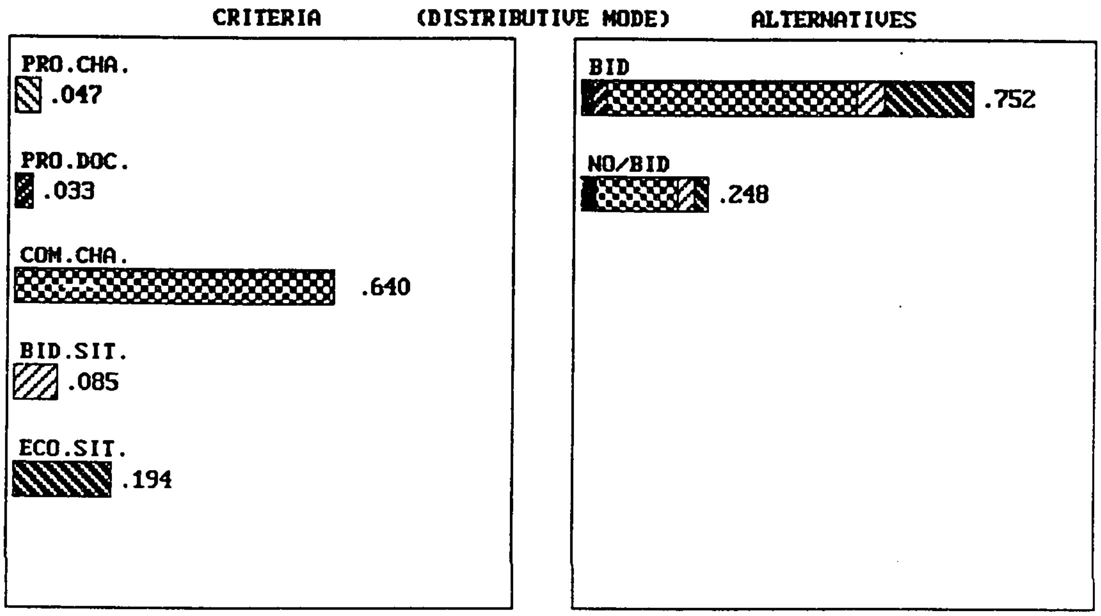


Fig. 30.3 : Change in Alternatives Priority due to change incompany characteristics priority .

4. The priority of bidding situation was changed from 0.157 to 0.226 (Fig. 30.4). As a result, the priority of bid alternative changed from 0.751 to 0.741 and the priority of no-bid alternative changed from 0.249 to 0.259.

5. The priority of economic situation was changed from 0.359 to 0.222 (Fig. 30.5). As a result, the priority of bid alternative changed from 0.751 to 0.728 and the priority of no-bid alternative changed from 0.249 to 0.272.

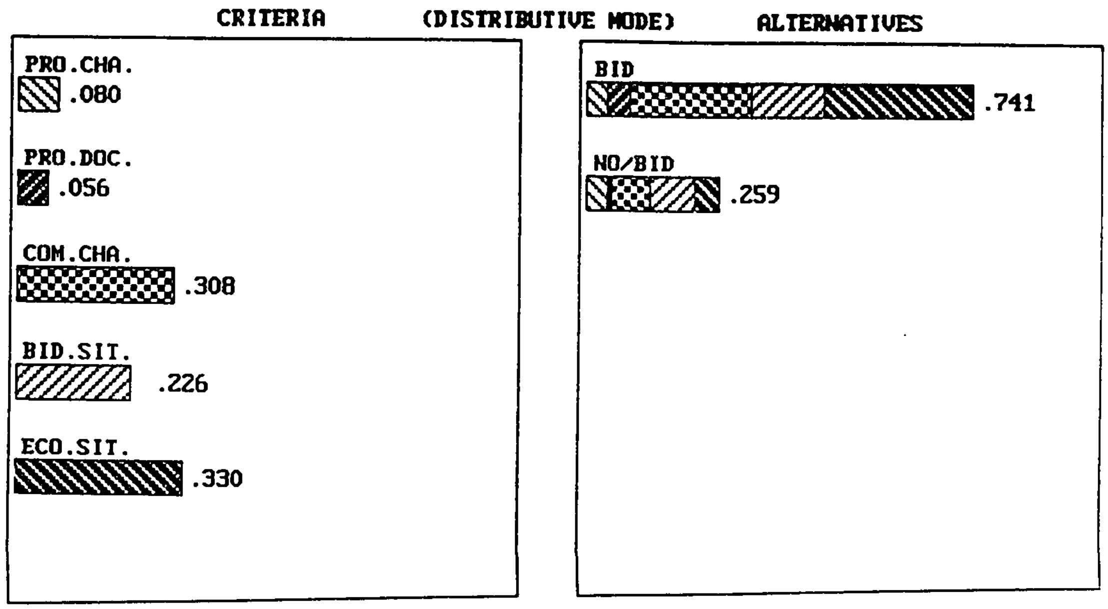


Fig. 30.4 : Change in Alternatives Priority due to change in bidding situation .

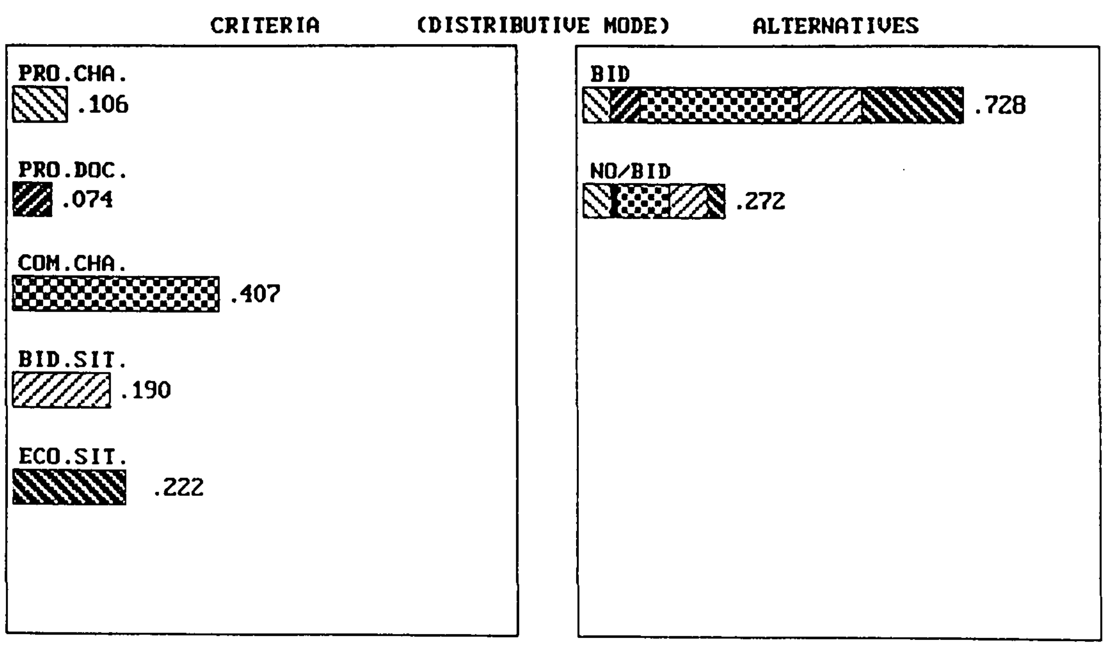


Fig. 30.5: Change in Alternatives Priority due to change in economic situation .

4.2.5.2 Gradient Sensitivity

Gradient analysis was performed to see the sensitivity of alternative's priority to change, with respect to the change in the model's main criteria priority as follows:

1. Priority of project characteristics was changed from 0.09 to 0.29 (Fig 31.1). As a result, the priority of bid alternative changed from 0.75 to 0.68 and the priority of no-bid alternative changed from 0.25 to 0.32.

2. The changes in the model's other main criteria (Figures 31.2, 31.3, 31.4) show no significant change in the priority of bid decision.

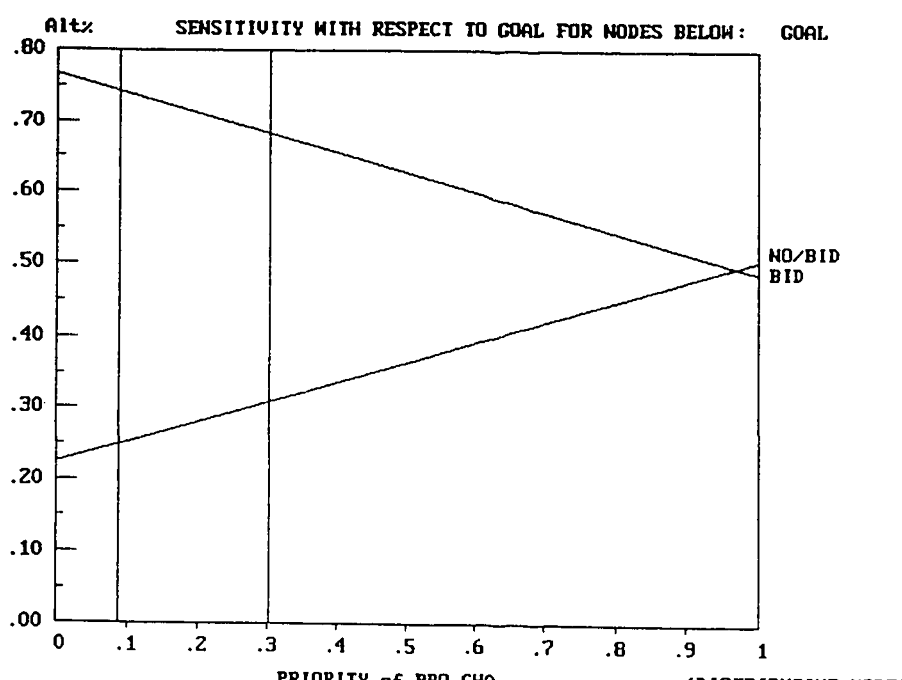


Fig 31.1 : Change in Alternatives Priority due to change in project characteristics priority .

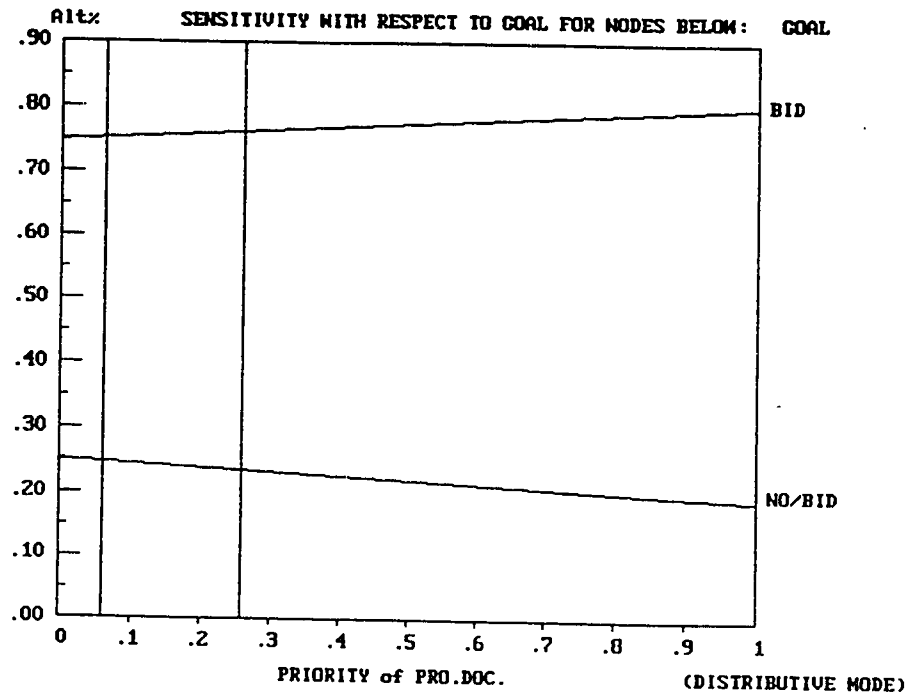


Fig 31.2 : Change in Alternatives Priority due to change in project documents .

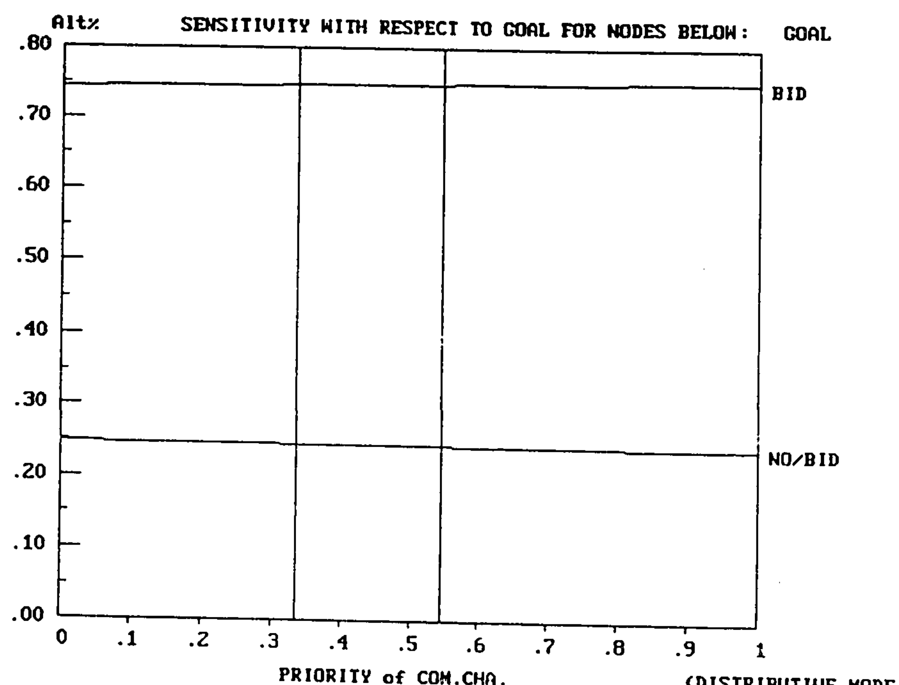


Fig 31.3 : Change in Alternatives Priority due to change in company characteristics priority .

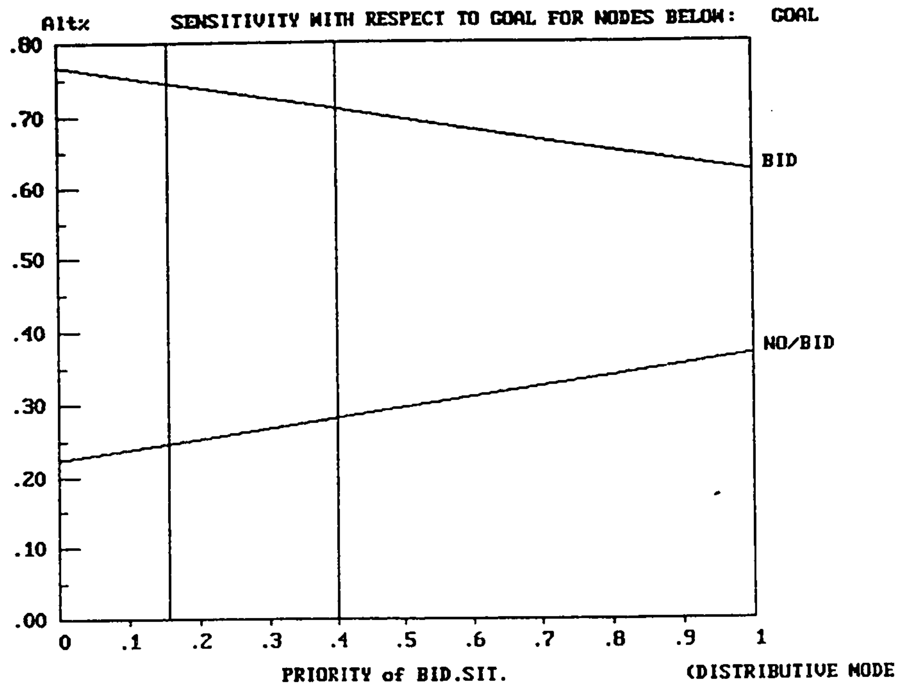


Fig 31.4 : Change in Alternatives Priority due to change in bidding situation .

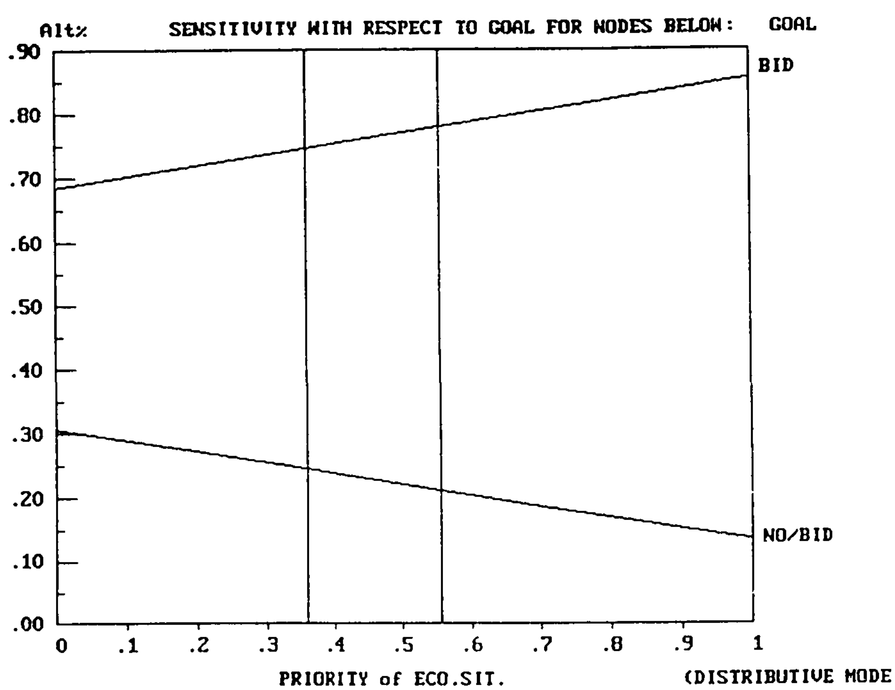


Fig. 31.5 : Change in Alternatives Priority due to change in economic situation .

4.2.5.3 Performance Sensitivity

The changes in the priority of Bid decision due to changes in the priorities of main criteria were insignificant (Figures 32.1, 32.2, 32.3, 32.4, and 32.5).

4.2.5.4 Two dimensional Plot

The two dimensional Plot was used to show how alternatives perform with respect to any pair of the models main criteria , as follows :

1. In the combination of Project Characteristics and Economic Situation (Fig 33.1), Bid Decision was excellent with respect to Economic Situation and good with respect to Project Characteristics.

2. In the combination of Economic Situation and Bidding Situation (Fig 33.2), Bid Decision was excellent with respect to both of them. No/bid decision is poor with respect to Economic Situation and average with respect to Bidding Situation.

3. In the combination of Company Characteristics and Bidding Situation (Fig 33.3), Bid Decision is excellent with respect to Company Characteristics and very good with respect to Bidding Situation. While No/Bid Decision was less than average with respect to both of them.

4. In the combination of Project Documents and Bid Situation (Fig 33.4), Bid Decision is excellent with respect to Project Documents and good with respect to

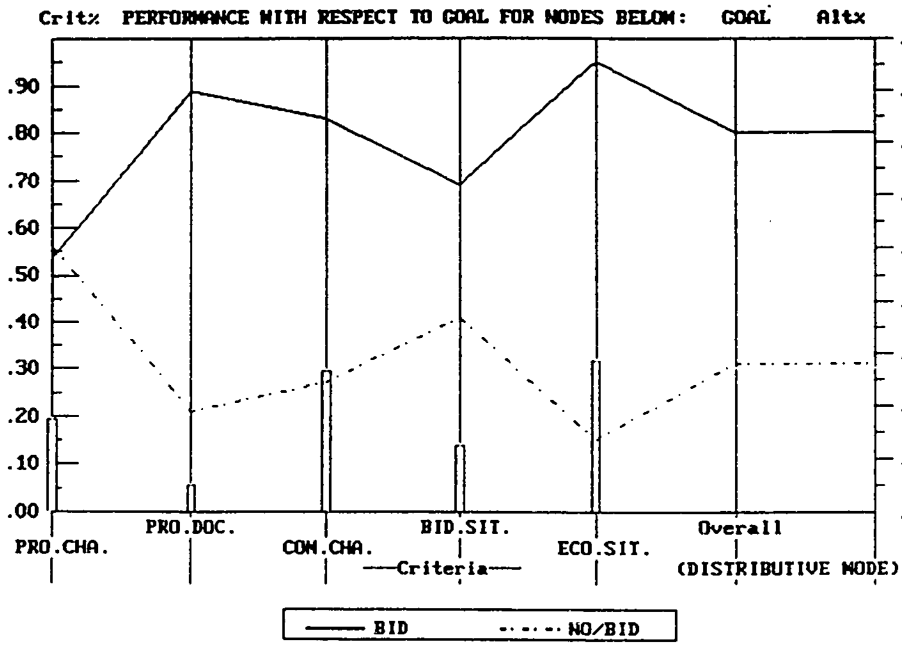


Fig 32.1 : Change in Alternatives Priority due to change in project characteristics priority .

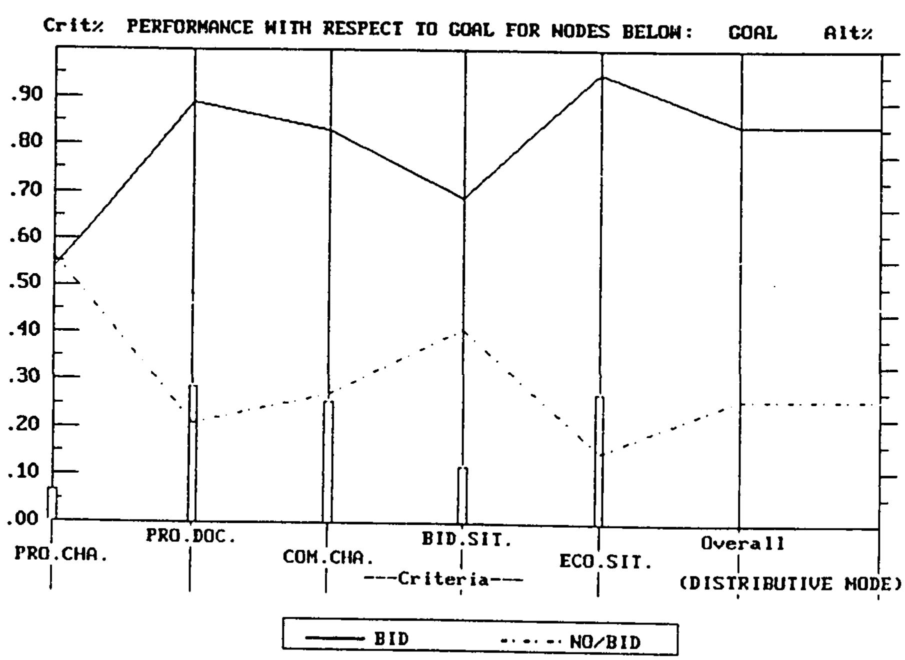


Fig 32.2 : Change in Alternatives Priority due to change in project documents .

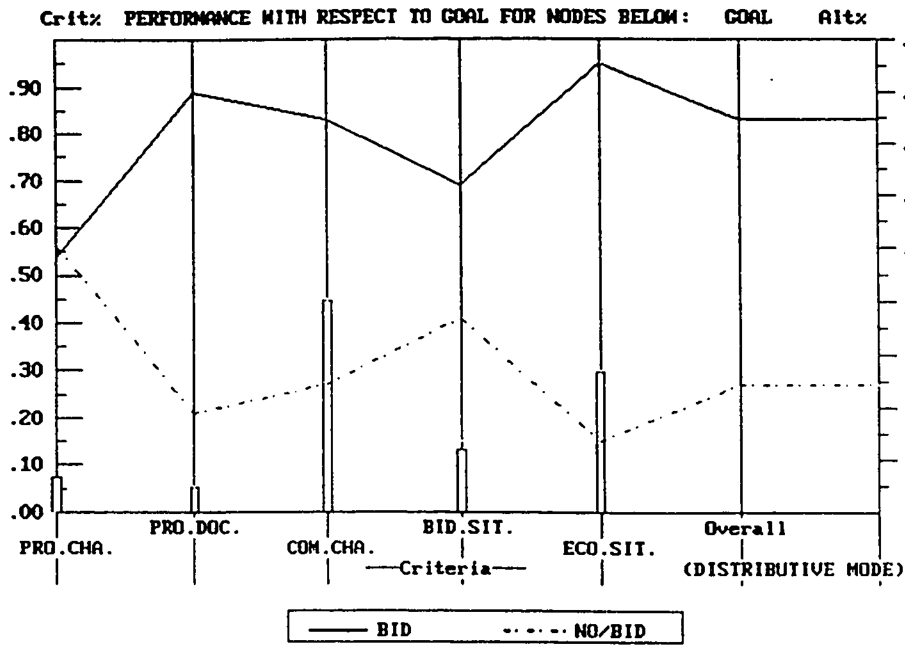


Fig 32.3 : Change in Alternatives Priority due to change in company characteristics priority .

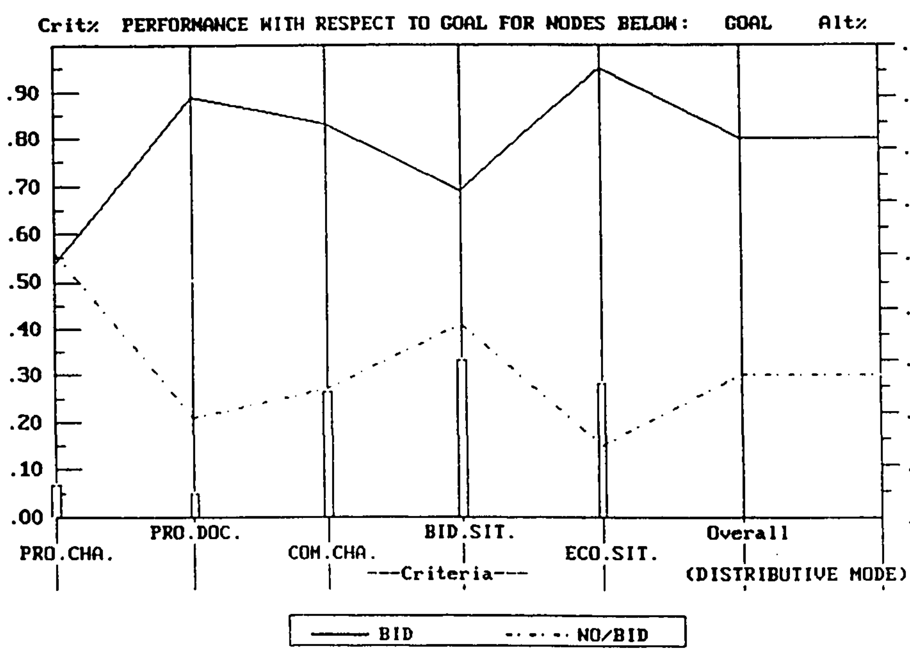


Fig 32.4 : Change in Alternatives Priority due to change in bidding situation .

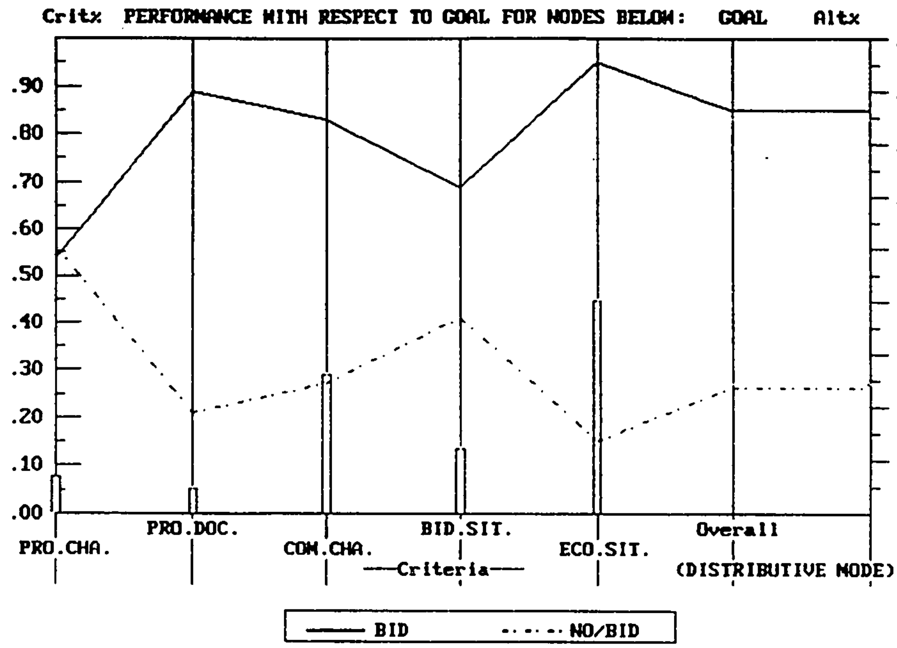


Fig 32.5 : Change in Alternatives Priority due to change in economic situation .

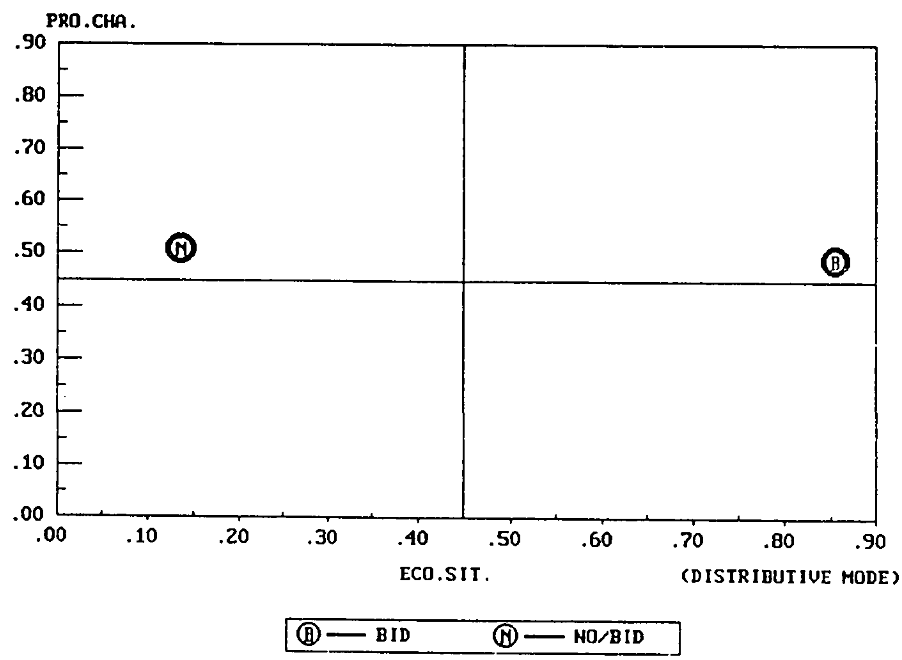


Fig 33.1 : Performance of project characteristics and economic situation with respect the alternatives .

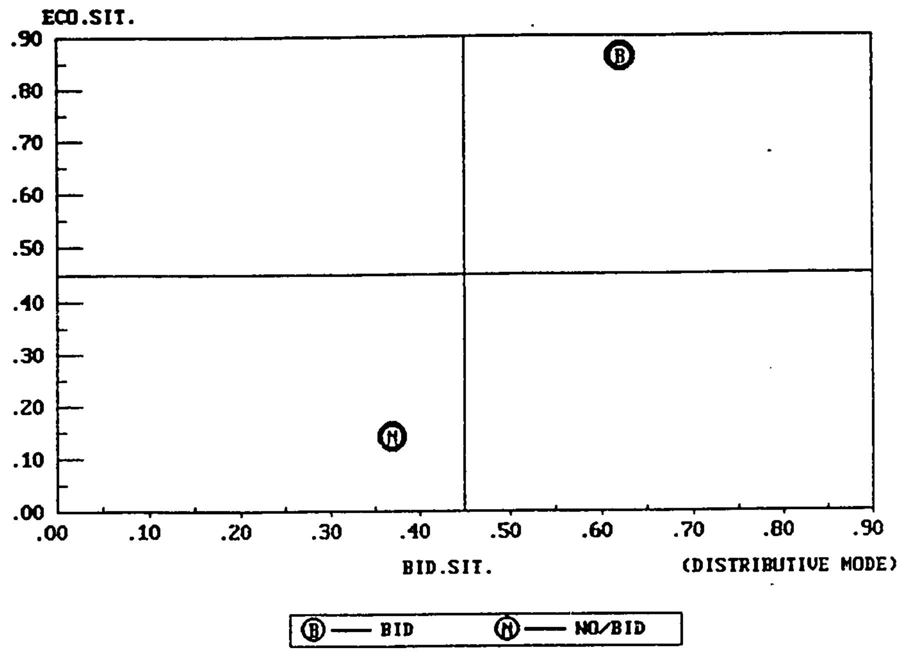


Fig 33.2 : Performance of economic situation and bidding situation with respect the alternatives .

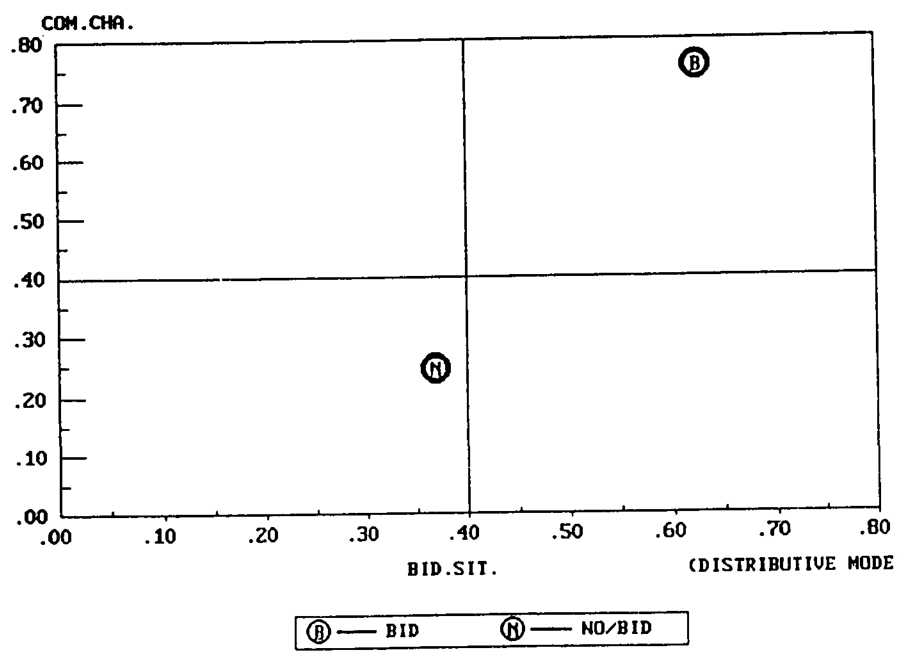


Fig 33.3 : Performance of company characteristics and bidding situation with respect the alternatives .

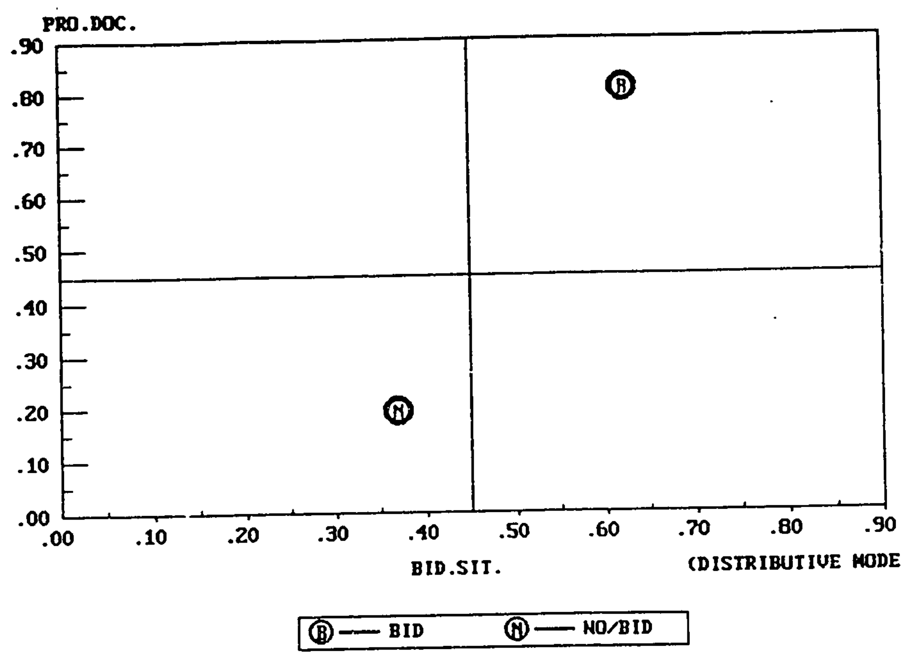


Fig 33.4 : Performance of project documents and bidding situation with respect the alternatives .

bidding Situation. No/Bid alternative was poor with respect to Project Documents and average with Bidding Situation.

4.2.5.5 Conclusion

The result of solving the model and the outcome of the sensitivity analysis modes support the Decision to Bid.

Summary and Recommendations

This chapter presents a summary of the study and recommendations.

A computerized model, based on the Analytic Hierarchy Process(AHP), was developed to help contractors working in the Kingdom of Saudi Arabia to make their bid/no-bid decision on a rational basis as it was evident from a questionnaire survey conducted among the top 400 contractors of the USA, that the bid/no-bid decision was made without any reasonable base. The model developed, is flexible enough to allow the addition of other bid/ no-bid factors as necessary to fit a particular contractor's situation.

Literature was reviewed for the purpose of accessing the factors that affect the bid/no-bid decision in the Kingdom of Saudi Arabia. Resulting from a previous questionnaire among contractors, thirty seven internal and external potential factors were identified affecting the contractor's bid/no-bid decision. These factors had been classified into five categories:-project characteristics, project documents, company characteristics, bidding situation, and economic situation.

The Analytic Hierarchy Process(AHP) basic principles and its application steps to come to a rational decision in complex problems were presented. An AHP based computer software, and the bid/no-bid decision factors were used to develop and solve the model to avoid excessive computations and to simplify the decision making process. The bid/no-bid model is an inverted tree hierarchy with bid decision at the top of the hierarchy. Bidding factor categories were inserted in the second level of the hierarchy and bidding factors were inserted in the third and fourth levels of the hierarchy. Finally the bid and no-bid decisions were inserted at the last level of the hierarchy as decision alternatives. To form a more complete picture of the problem an information screen for each factor affecting the bidding decision was established. This information was collected by the company decision maker from the various departments of the company, and served as a base for developing judgments throughout the model.

Judgments throughout the model were made and the model was solved. The model result supports the decision to bid on the mentioned project with a priority of 75%.

5.1 Recommendations

Contractors working in Saudi Arabia are recommended to use this computerized model for the following reasons:

1. The standard form of the model is ready, contractors only need to enter their judgments.

2. Time is saved by using the mathematical capability of the computer in calculations.

3. Model rational decision can result in potential savings.

4. The model is flexible and easy to modify to add any other factors.

5. Judgements can be made in group sessions in large and complicated projects.

Appendix (1)

Information Screens

A- Project Characteristics

1- Cash Flow:

- Negative for total contract period of 24 months with 9 millions at peak.
- 50% cash would have to be drawn on bank overdraft at 15% interest rate.
- 15% retention is a large amount.

2- Size of contract:

- SR 200 millions ,involving at peak 663 men.
- Within MSAS capabilities.
- 10% penalty is a large risk.

3- Contract duration:

- Duration of contract is 24 months ,site duration is 18 months which is a good construction period.

4- Type of Equipment Required:

- Required equipment are available.

5- Owner:

- Medical and Cosmetic Products Co. (MCPC).
- No previous experience with this company , and there is no objection to deal with it.

6- Project Location:

- 2nd industrial city, Riyadh, KSA.
- MSAS have at present small office in Riyadh and an existing contract at Riyadh refinery.
- MSAS wishes to establish itself as a major onstruction firm in Riyadh area.

- Initial cost of setting our own camp.
- High cost of mobilization of equipment and manpower.
- High cost of back-up services during contract period.

7- Job start time:

- Three months after bidding.
- MSAS existing civil contracts are coming to an end, and their manpower can be transferred to this contract instead of terminating them.

B- Project Documents

1- Owner special requirements:

- Not applicable.

2- Type of Contract:

- Lump sum procure and build.

3- Design Quality:

- Detailed design is required, and construction drawings have to be produced by MSAS.
- MSAS will have to employ the services of an outside firm to cover the design requirements.

4- Designer (A/E):

- No previous experience with him, and there is no objection to deal with.

C- Company Characteristics

1- Availability of required cash:

- Cash would be readily available.
- High cost of financing would adversely affect our bid price.

2- Uncertainty in Cost Estimate:

- Bill of quantities are not guaranteed by the client, and all quantities will be measured from drawing.
- MSAS will employ staff experienced in pharmaceutical work.
- MSAS will have to employ quality controllers for overse as procurement.
- Rock excavation is risky.

3- Need for Work:

- MSAS requires major civil contracts to keep the existing civil staff working.

4- Experience in Such Projects:

- MSAS had not executed a pharmaceutical plant, but it has the necessary experience in executing the construction of buildings and services.

5- Confidence in Work Force:

- MSAS have 6000 employees, the hard-core of this force have a great deal of experience and they worked for years with the company.

6- Strength in Industry:

- MSAS is very strong in all aspects of construction.

7- Past Profit in Similar Projects:

- Usually not so good due to delays in receiving drawings and change orders.

8- General Office Overhead:

- Due to our high head office overheads, the turnover of this project is needed to reduce the overall percentage in our mark-up.

9- Current Work Load:

- Although MSAS has sufficient work load (at the moment), a follow on civil contracts is required.

10- Availability of Qualified Staff:

- Bulk of the staff is available.

11- Establishing Long Relation with Clients:

- Owner is not expected to build more pharmaceutical plants in Saudi Arabia.

12- Reliability of Subcontractors:

- MSAS has confidence in most of subcontractors needed.

13- Portion Subcontracted to Others:

- The pharmaceutical plant will be subcontracted ,which is the core of the project.

14- Public Exposure:

- MSAS will benefit from executing this prestige contract.
- There are many similar projects(secondary developments) scheduled to be built in the Kingdom within the next five years.

D- Bidding Situation

1- Required Bond Capacity:

- No performance bond is required.
- 15% retention is required.
- No advance payment.
- Maximum penalty is 10%.

2- Competition:

- Competition would not be too severe due to adverse payment conditions and negative cash flow.

- 5 major Saudi based international contractors will join bidding, which is good in present market.

3- Time of Submitting Bids:

- appears reasonable.

4- Bidding Document Price:

- It is free.

5- Time of Bidding:

- The season is right for bidding, because if the project stays on target, we will be out of the basement before the wet season.

6- Prequalification Requirements:

- MSAS had been prequalified for this project by the owner.

E- Economic Situation

1- Availability of Equipment:

- The majority of equipment are available.
- A tower crane would be purchased.

2- Overall Economy (availability of work):

- There is a downturn in the market.
- Number of bids is decreasing each month and this could result in a very competitive price to win this contract.

3- Risk Involved in Investment:

- There is no major risk.

4- Governmental Division Requirements:

- Not applicable.

5- Quality of Available Labor:

- MSAS labor force is well experienced in such projects.

- This project will keep our trained labor employed.
- Loosing this trained labor force will restrict our chances in future bids.
- Would save bringing untrained labor in the future.

6- Availability of Labor:

- The needed labor force is available from existing sites within the next 3 months ,which suits the program.
- Getting the job will save the cost of sending labor force home.

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